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SOME POINTS IN THE PATHOLOGY OF "BONE CYSTS" IN THE ACCESSORY SINUSES OF THE NOSE.*

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Mr. Chairman and Gentlemen:—The subject of my paper today deals with a pathological condition of the accessory nasal sinuses which presents many points of considerable interest. For want of a better descriptive title I have included under the term "Bone Cysts" those cases of cyst-like distension of the air sinuses which are from time to time met with and which must be regarded as a pathological condition distinct from the suppurative affection of the sinuses. I have discussed this subject elsewhere† at some length, but ask the consideration of the meeting to some of the more important points connected with the etiology of the condition.

Distention of the walls of the ethmoid cell labyrinth, of the frontal sinus, and of the antrum of Highmore, has been described, but, so far as I have been able to ascertain, no similar condition of the sphenoidal sinus has been met with. The condition is the same in its clinical course and in its origin whichever cavity is affected. Thus we find clinically in the first place that the patient has probably been conscious of the existence of some abnormal condition for a very considerable period of time, possibly for years. The course of the disease is therefore a slow one. The swelling due to the expansion of the bony wall of the cavity increases very gradually and sometimes there are periods during which the condition appears to remain stationary. The painless nature of the affection is also characteristic,

* Read at the Tenth Annual Meeting of the American Laryngological, Rhinological and Otological Society held at Chicago, May 30, 31 and June 1, 1904.

† *Edinburgh Med. Journ.*, October, November, December, 1903, January, 1904.

associated as it commonly is with the absence of any tenderness on palpation. As a rule therefore there are no acute inflammatory phenomena present.

Again, a common mode of origin is probably also to be found in all these cases, though one important exception will require to be presently considered, in connection with the antrum of Highmore. In all probability a chronic inflammatory process is set up both in the bony wall and in the lining mucous membrane of the air sinus, while the ostium of the cavity becomes partially or completely occluded. There is microscopic evidence of the occurrence of inflammatory changes in the wall of the sinus. The initial cause of the inflammation, however, is more difficult to ascertain. As the osteitis develops, we find that a process of bone absorption takes place upon the inner aspect of the wall, that is, next to the interior of the cavity due to the action of osteoclast cells. On its outer aspect, on the other hand, fresh bone is being slowly deposited by osteoblast cells. Simultaneously with the changes in the wall of the sinus, an accumulation of mucous secretion may go on within the interior of the cavity if the normal opening to the nose has become occluded. In this manner a slowly progressive distention of the air space takes place and if the process is allowed to continue sufficiently long, thinning and absorption of one or more of the bony walls takes place. As a rule the weakest wall of the cavity is the first to give way.

An analysis of the various published cases illustrating this condition reveals the interesting fact that in some, the bony cavity merely contains air, in others, the contents are of a mucoid character, while in a third group of cases pus or muco-pus is found. It is not difficult to find an explanation of these facts. When the cavity is empty, it is probable that the normal aperture of communication with the nose has never been occluded. Consequently, no accumulation of secretion takes place within it. On the other hand, in the second group of cases, the mucus accumulates in consequence of the closure of the sinus, the resulting distension in this group of cases constituting the so-called "mucocele." Occasionally an escape of part of the contents may take place at intervals into the nose. When pus or muco-pus is met with as in the third group, we have merely to deal with an organismal infection of the previously existing mucoid contents of the cavity. Such is a very brief description of the general pathological conditions found in connection with this affection in the different sinuses. We must next turn to a consideration of some of the special features which characterize it in the individual sinuses.

The Ethmoidal Cell Labyrinth: (*a*) *The Inferior Ethmo-turbinated Bone.*—In discussing the question of "Bone Cysts" of the

ethmoidal air spaces, it is necessary to bear in mind that the air cells grouped under this term consist of those that are found in the middle turbinated bone of the nose, and those occurring in the lateral mass of the ethmoid bone. This differentiation is necessary, because clinically, the cases of distention present features which distinguish them markedly from each other, although the same pathological basis exists in both. The middle turbinated bone is merely a part of the ethmoid bone of the skull and is more correctly designated as the inferior ethmo-turbinated. In a certain proportion of skulls this bone contains in its interior one or more air spaces which must be regarded as integral parts of the ethmoidal system of air spaces. These cells were referred to by Santorini, and have been more minutely described by Zuckerkandl, Stier, Lothrop and others. Lothrop in his most recent admirable work* upon the anatomy of the

Fig. 1.

Left middle turbinated bone, showing air spaces in its interior.

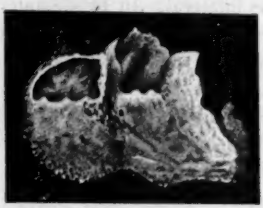

Fig. 2.

Left middle turbinated bone in profile.

inferior ethmo-turbinated bone, found in 1000 bones examined that an air cell was present in 89 or in 9%. In 1% the cell existed on both sides of the skull; he further found that it was rather more commonly met with in the right than in the left middle turbinated bone. My own observations on this point have been limited to the examination of 160 skulls, of which 112 were male and 48 female. In 32 skulls, *i. e.*, in 20%, there was evidence of the existence of a middle turbinated air space. Like Lothrop I found the cell rather more frequently on the right than on the left side. In eight instances the condition was bilateral. The cells were present in 20, or in 17% of the 112 male skulls, and in 12, or 25% of the female skulls. I was unable to detect any difference between the relative size of the air spaces in the skulls of the two sexes. While these figures show

* Annals of Surgery, August, 1903.

that a larger number of air cells occur in the female skulls, the numbers are too small to permit of us drawing definite conclusions upon this point.

There is, however, abundant evidence of the occasional presence of an air space in the inferior ethmo-turbinated bone, and consequently, whatever may be the precise etiological factor concerned in the development of the "bone cyst" in any particular case, we have an anatomical basis to explain the existence of a cavity in this situation. Much interesting discussion has taken place over this point.

Perusal of the literature dealing with cyst-like distension of the middle turbinal, so far as I have been able to gain access to it, furnishes me with the report of 46 cases, though a number of other instances have undoubtedly been met with. Of the 46 cases 26 occurred in women and seven in men, the sex in the remaining 13 cases not being stated. The female sex, therefore, shows a considerable preponderance. In 14 instances, the right, and in 16 the left middle turbinated bone was the seat of the affection, while in five the condition was bilateral. In 14 no statement is made regarding the side of the nose affected. In 24 cases the age of the patient is stated; thus, the youngest was 16 and the eldest 65 years of age. Three were below 20, and four above 40 years of age; the majority, therefore, were in middle life. The condition has not been observed in childhood.

In regard to the origin of a small number of these cases, there is evidence to show, I think, that the condition is not a strictly pathological one; but rather the result of an excessive anatomical development or overgrowth of the normally existing air space. Variations in the development of the ethmoidal air cells and in indeed in all the accessory sinuses, is very common; it is hardly necessary to cite particular instances of this and we may regard the occasional occurrence of a large air space in the inferior ethmo-turbinated as an example of an anatomical variation. A case reported by Payson Clark* illustrates this point. Shambaugh has also brought evidence in support of this contention. In Clark's case each middle turbinated bone contained an empty cavity, the walls of which showed no evidence of inflammatory changes.

While an anatomical variation explains the origin of a few of these cases, there is abundant proof of the inflammatory nature of the majority of them. Sundholm, Beausoleil, Knight and others bring evidence in support of this. I have already referred to the changes which occur in the walls of the cavity, but the explanation of the cause of the inflammatory process is still wanted. In some of the cases of so-called "bone cyst" of the middle turbinated, the

* Trans. Amer. Lar. Association, 1900.

symptoms appear to have been due to the coexistence of nasal polypi rather than to the presence of any abnormal distension of the air space. Most of us can recall cases of nasal polypi in which, in the course of operative interference, we found that the middle turbinated bone appeared to be enlarged and contained in its interior an air space of some size. In a case of "bone cyst" recorded by Newcomb, and in one of Sundholm's patients, I think there is evidence to show that the polypi were the cause of the symptoms, the cavity in the bone being of normal anatomical proportions. In neither case did the wall show any evidence of rarefying osteitis. On the other

Fig. 3.

Preparation showing great dilatation of the right middle turbinated air space.

hand there are cases of nasal polypi associated with enlargement of the middle turbinated air space showing inflammatory changes in its osseous wall, and a polypoid condition both of the lining membrane of the cavity and of the outer mucous covering of the bone. I am aware that in introducing these facts I am touching upon a larger subject, but it is not the object of this paper to enter upon the much discussed question of the origin of nasal polypi, however interesting it may be.

The chief symptom complained of by a patient suffering from distension of the middle turbinated air cell are usually those of gradually increasing nasal obstruction, commonly unilateral, and pain varying in degree and in situation, sometimes of the nature of headache of a very severe type. Intra-nasal examination reveals a swelling of varying size presenting a smooth uniform surface, perhaps of a somewhat paler color than the normal mucosa. In some cases, it may be at once evident from the position and contour of the swelling that it is the middle turbinated body, but when the enlargement is considerable, it is not always easy by mere inspection to determine its origin. It may simulate a deviation of the septum, until the opposite nostril is examined. When large it may press the septum into the nasal cavity of the opposite side. Pressure with the probe may disclose the yielding character of the wall of the swelling, or if a doubt should still remain regarding its exact nature, exploratory puncture with a trochar and cannula will clear up its cystic or solid nature. In a case under my own care, the left nasal bone was displaced and the nasal wall of the maxillary sinus was absorbed, so large was the turbinal cyst.

Distension of the Air Cells Situated in the Lateral Mass of the Ethmoid Bone.—If we turn next to the air spaces in this situation we find evidence of distension of the cavity mainly if not entirely in the region of the orbit. Consequently the symptoms are referable to the eye rather than to the nose and the patient seeks in the first instance the advice of the oculist. The ethmoidal cells are intimately related to the inner wall of the orbit, the thin plate of bone or *lamina papyracea*, which forms the outer boundary of the cell labyrinth, being at the same time the inner wall of the orbital cavity. The ethmoidal cells, however, are not confined to the ethmoid bone itself, but may invade the frontal bone, extending outwards into its horizontal orbital plate. This extension is not an uncommon occurrence and must be remembered in connection with the subject now under discussion.

The swelling formed by the distension of the ethmoidal air space occupies the inner angle of the orbital cavity in the neighborhood of the internal canthus. Its exact position varies somewhat in different cases; if we bear in mind the occasional orbital extension of the ethmoid labyrinth, it is easy to understand how the swelling may occupy the position which we commonly associate with a similar affection of the frontal sinus.

The swelling varies in size and the skin covering it presents a normal appearance and is freely movable upon it. Towards the periphery it is of a firm osseous consistence, but palpation of the

apex of the swelling may give a semi-fluctuating elastic sensation. There may be an entire absence of intranasal symptoms and signs; in the cases described by Ewetzky, Baurowicz and Avellis, however, there was evidence also of distension of the ethmoid labyrinth into the nasal cavity.

I have been able to analyze 15 cases of this affection to which the term ethmoidal 'mucocele" might be justly applied. Of these, eight

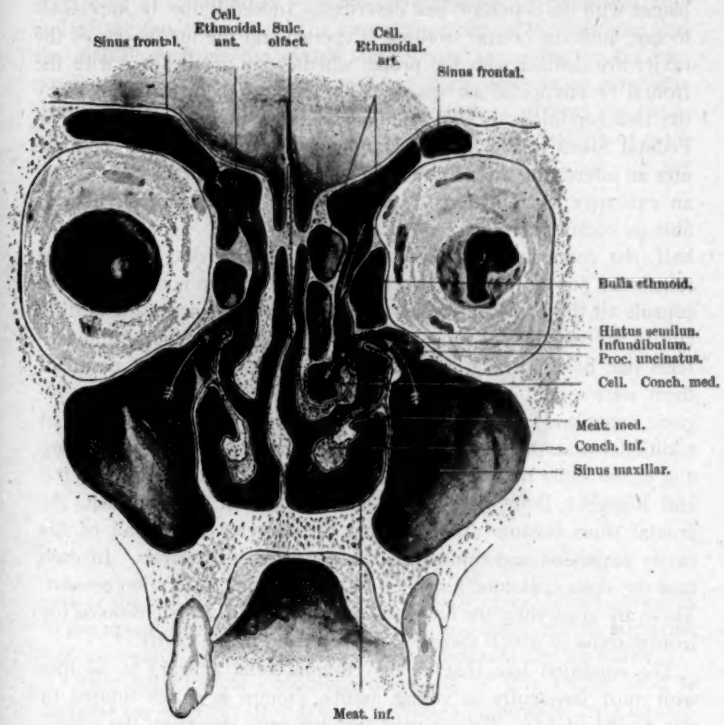

Fig. 4.

A vertical coronal section through both nasal chambers viewed from behind. On the right side the middle turbinated air space is seen communicating with the middle meatus.

occurred in males and six in females, the sex, in one, not being stated. The period of life at which the condition is observed is not without interest. The majority of the cases occurred during adolescence. Thus, of the 14 in which the age was recorded, ten were met with between the age of 12 and 20, three between 20 and 30, and one, the oldest in the series, was only 32 years of age. As

regards the side of the nose affected, information on this point is to be found in 11 of the cases. In one the affection was bilateral; in ten, unilateral, the right side being affected in four and the left in six. In all, with two exceptions, the contents of the distended cavity were of a mucoid character, having a viscid tenacious consistence.

Distension of the Frontal Air Sinus has many points of resemblance with the condition just described. Indeed it may be impossible to say, until the orbital swelling is opened and the limitations of the cavity are defined with the probe, whether we are dealing with the frontal or ethmoidal air spaces. The clinical picture presented by the two conditions is very similar. Killian in his article on The Frontal Sinus in Heymann's Handbuch der Laryngologie, contributes an interesting article upon distension of the frontal sinus. From an extensive examination of the literature of the subject, he was able to obtain reference to 64 cases of this kind. In at least one-half, the contents of the cavity consisted of mucus, while in the remainder pus or muco-pus was found. As I have not been able to consult all the papers to which he apparently had access, it is difficult to say whether, in those cases in which pus was found, the contents had been purulent from the outset or whether some or all of them were examples of "mucocele" secondarily infected with pyogenic organisms. I have been able to add a considerable number of additional cases to these. Undoubtedly two of the most interesting and at the same time very rare cases are those reported by Meyjes[1] and Röpke[2]. Both were young adult males æt. 18; in each, the frontal sinus became distended and the anterior bony wall of the cavity expanded and thinned to the consistence of paper. In each case the sinus contained air, there being no trace of secretion present. These are apparently the only two recorded cases of distension of the frontal sinus in which there was no secretion in the cavity.

The condition like that in the ethmoid cells appears to be met with most frequently in young adults, though it is not limited to this period of life. Bellingham[3], for instance, describes the condition in a male æt. 46, and Luc's[4] patient was 56 years of age. One cannot fail to be struck by the age of the cases reported by Steiner[5] and W. H. Jessop.[6] The one was a girl æt. 7, the other a girl æt. 10 years. It is generally held that the frontal sinuses commence to develop at the end of the first or at the beginning of the second year of life as an upward expansion of the ethmoid cell labyrinth. It is

3 Quoted in Schmidt's Jahrb., Leipzig, Bd., 83.
4 *Ann. d. Mal. de l'Oreille*, etc., Paris, April, 1888.
5 *Zeitschr. f. Chirurg.*, 1871.
6 Trans. Ophth. Soc. U. Kingdom, London, 1901, 1897.

not until the sixth or seventh year that the cavity reaches above the supra-orbital margin and is present in the vertical portion of the frontal bone. The development of a "mucocele" of the frontal sinus at the age of 7 years is therefore specially interesting. With regard to the relative frequency of the occurrence of the condition in the two sexes, it appears to be found more or less equally in both.

Differential Diagnosis.—As I have already indicated, it is not always easy to differentiate between distension of the ethmoidal cells and of the frontal sinus. The situation of the orbital swelling and the displacement of the eyeball may differ somewhat in the two conditions, but the difference may be so slight as to be of very little diagnostic value. When the ethmoid labyrinth is affected the swelling tends to lie nearer the inner canthus and in the majority of cases the displacement of the eyeball is forwards and outwards. In the

Fig. 5.
Skull showing extension of ethmoid cells into orbital plate of frontal bone.

case of the frontal sinus, the swelling extends upwards and outwards in the upper eyelid, occupying its middle and inner thirds, while the displacement of the globe is downwards, outwards and forwards.

Other pathological conditions occurring in this region tend to increase the difficulty of diagnosis. Thus, a "mucocele" may be mistaken for an exostosis, especially in the earlier stage of the affection before the bony wall of the sinus has given way and a fluctuating area can be palpated. The difficulty is increased by the presence of the subperiosteal thickening which is found in cases of distension of the wall of the sinus. Even before the bony shell of the cavity has disappeared, however, there is usually a slight degree of compressibility not apparent in an exostosis or a fibrous tumor.

Cystic dilatation of the tear sac may occur and simulate to some extent the sinus affection. In the former, however, the swelling

can be made somewhat smaller by pressure and the mucous is expressed into the nose. Again, the tears do not escape properly, but tend to flow onto the cheek. Dermoid cysts may occur in this situation, but being of congenital origin, the history of the case will assist in clearing up the diagnosis. A dermoid cyst may absorb the bone behind it, and even invade and expand the frontal sinus. Steiner refers to a case of this kind, which is reported by Gilibert.

The Maxillary Antrum.—In discussing the question of distension of the maxillary sinus we tread upon more debatable ground. We must ask ourselves at the outset as to what pathological and clinical evidence there is in support of the occurrence of such a condition.

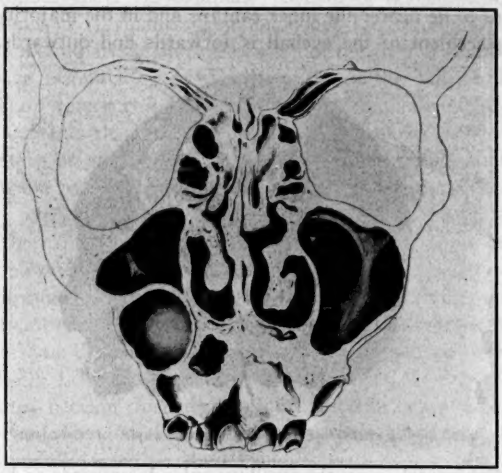

Fig. 6.

Vertical transverse section through both maxillary antra viewed from behind.—(Zuckerkandl.) Lower part of left antrum is occupied by a bony cyst, which is encroaching upon antral cavity and left nasal cavity. A second cyst connected with canine tooth causes bulging of hard palate.

When we meet with a case of expansion and thinning of the facial and palatal walls of the superior maxilla, have we really to deal with a true distension of the antral cavity itself, analogous to what we have described in the ethmoid and frontal sinuses? The possibility of the occurrence of a 'mucocele" of the antrum due to the occlusion of its ostium has been discussed by several writers. Killian appears to accept it as a pathological entity but admits that owing to the rarity of the condition the anatomical changes which take place are not easy to study. Zuckerkandl, who considers that

distension of the antrum is outside the range of discussion, figures in his work on the nasal cavities a specimen which apparently illustrates the condition. The outer wall of the middle meatus on the right side is bulged into the nasal cavity; there is no ostium maxillare visible; the right antrum contained a quantity of thick pus, its lining membrane was swollen and the mucous glands showed evidence of cystic degeneration.

Dmochowski* describes a specimen which throws more light upon the possible occurrence of distension of the antral cavity. The

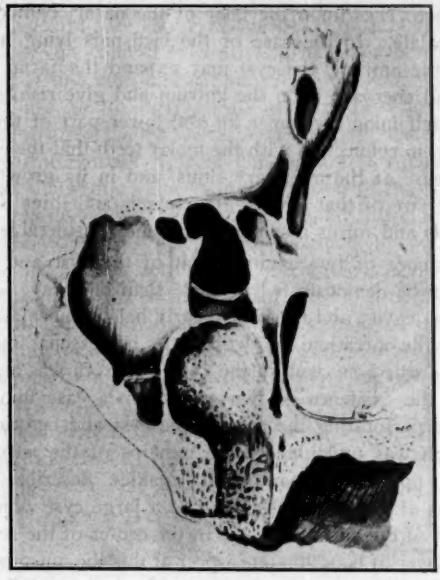

Fig. 7.

Transverse vertical section through left superior maxilla viewed from behind.— (Zuckerkandl.) Socket of Second molar leads up into a cyst cavity, which is encroaching upon cavity of antrum.

preparation was removed from a young woman; the left ostium maxillare was completely obliterated; the cavity was filled with a quantity of clear yellow fluid, and the walls of the sinus were so thin that they could be indented by the slightest pressure. The lining mucosa was pale and thin and no mucous glands were to be found in it.

Although these facts undoubtedly furnish *post mortem* evidence of the occurrence of true distension of the antral cavity, I think we

* Arch. f. Laryngol., Berlin, 1895, Bd. III.

will all agree that the condition is a rare one and that the cases from time to time met with in which the walls of the antrum have become distended, are really examples of cysts connected with the teeth. These cysts in their growth encroach upon the cavity of the antrum, diminish its size even to the extent of obliterating it, expanding one or more of its walls in the process.

In support of this, there is abundant pathological and clinical evidence. Zuckerkandl's preparations illustrate many varieties of tooth cysts. If developing in connection with the incisor teeth, the cyst encroaches upon the floor of the nasal chamber and upon the hard palate. In the case of the bicuspids lying in close contiguity to the antrum, the cyst may expand the facial wall of the alveolus and encroach upon the antrum and give rise to a swelling showing itself upon the upper lip and lower part of the cheek. It is, however, in connection with the molar teeth that the cyst enlarges at the expense of the maxillary sinus, and in its growth gradually reduces the size of that cavity. It expands and thins its facial and palatal walls and forms a swelling of some considerable size.

The existence of two cavities, that of the cyst and that of the antrum, can be demonstrated in more than one way. I have seen both the cyst cavity and the sinus nearly half its normal size opened into during the operation, the two cavities being separated from each other by the true bony wall of the cyst. Billroth was able to satisfy himself of the existence of two cavities in a case upon which he operated by perforating the roof of the cyst and entering a second cavity which was undoubtedly the remains of the antrum not yet encroached upon. Heymann and Coakley describe microscopic preparations of portions of the wall of a large cyst which filled the greater part of the antral cavity. In the center of the sections there was a thin layer of bone; on one aspect of this the mucous membrane, covered with ciliated epithelium, presented the usual appearance of the lining membrane of the antrum; while on the other aspect of the bone was the lining membrane of the cyst proper, with its epithelium arranged in two or three layers of flattened pavement cells, clearly demonstrating histologically not only that two cavities were present, but also their nature.

If further evidence were wanted in support of the dental origin of these "bone cysts" rather than in their development as a true distension of the antrum, we have it in the following additional fact. The outer wall of the middle meatus of the nose is the weakest part of the boundary of the antrum. In true distension of that cavity we would naturally expect the inner nasal wall to expand and

yield first. The roof of the antrum or the floor of the orbit occupies an intermediate position as regards thickness, between the nasal and facial walls of the sinus, and would also expand in such a condition. Clinical experience, however, goes to show that it is in the region of the canine fossa or facial wall that expansion most frequently takes place, and that seldom if ever do we see any bulging of the weaker nasal and orbital walls.

Sometimes the facial wall, distended and thickened by the growth of the cyst gives way and the contents of the cavity escaping into the mouth becomes infected with the result that the patient becomes conscious of a foetid bad tasting discharge. Considerable confusion sometimes arises in connection with the diagnosis between a suppurating cyst of this kind and chronic suppuration of the maxillary sinus. How are we to distinguish between the two conditions? Certain features undoubtedly characterize the cystic distension which enable us to differentiate it from chronic antral suppuration. A point of great diagnostic value is the expansion of the bony wall of the antrum, associated with a fistulous opening through which the patient is able to express the purulent contents by pressure upon the cheek. I have never seen a case of chronic antral suppuration associated with distension of the walls of the antral cavity, Kennert lays considerable stress upon this point. Thinning of the bony wall perhaps yielding on pressure and of a crackling sensation is additional evidence of its cystic nature and does not occur in simple antral abscess.

Further the absence of any communication between the suppurating cavity and the nasal cavity is further proof, I think, that we are dealing with a tooth cyst which has become infected and is suppurating.

THE APPLIED ANATOMY OF THE FRONTAL SINUS.*

BY HARRIS PEYTON MOSHER, M.D., BOSTON, MASS.

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From the laboratory of the Anatomical Department.

The material for this paper is derived from a condensation and rearrangement of the chapter on the frontal sinus in the book on the anatomy of the sinuses published by Sieur and Jacob and from the study of the floor of the sinus on one hundred heads, and fifty cleaned skulls in the laboratory of the Harvard Medical School. The drawings are by the writer and where they are not credited to others they are from the writer's specimens. The aim of the paper is to give the applied anatomy of the frontal sinus with especial reference to the anatomy of the floor.

There are two frontal sinuses, a right and a left. They are separated by a median partition which corresponds to the saggital suture of the skull. The sinuses are placed in the middle and inferior part of the anterior face of the frontal bone. Each sinus represents the termination of the anterior part of the ethmoidal labyrinth of which it is an off-shoot. The sinuses stretch like wings transversely over the anterior portion of the orbit. They can be represented diagramatically by drawing an arc which has for its center the mid-point of the base of the nasal bones and extends from the middle of one supra orbital ridge to the middle of the other.

A horizontal section of the skull shows that the sinuses have the form of a triangular pyramid. The base of the pyramid is in the middle line while the apex extends outwards a variable distance over the orbit. There are, therefore, three sides or faces to the sinus, the anterior face which is sub-cutaneous, the posterior or cerebral face and the inferior or orbito-nasal face. In the posterior inferior angle of the pyramid, the width of the corresponding half the ethmoidal notch from the median septum there is an opening which connects the cavity of the sinus with the nose. See Fig. No. 1 and Fig No. 2.

All recent studies tend to demonstrate that the frontal sinuses are ethmoidal cells which have insinuated themselves between the two

* Candidate's Thesis for the American Laryngological Association presented at Atlantic City, N. J. June 2, 1904.

Fig. No. 1.—Sieur and Jacob.
Figure showing the pyramidal form of the sinus.

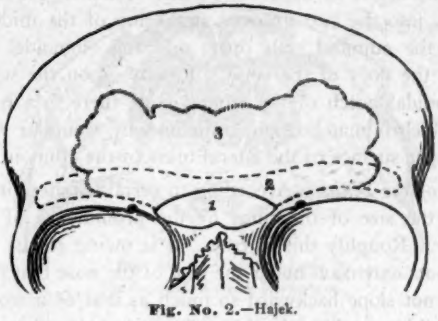


Fig. No. 2.—Hajek.
Diagrammatic figure showing the varieties of the large frontal sinus.

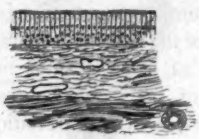


Fig. No. 3.
The mucous membrane of the frontal sinus.

Fig. No. 4.—Piersol.
The respiratory mucous membrane.

tables of the frontal bone. The following facts support this view: The development of the sinuses corresponds in time with that of the ethmoid cells. The sinuses are not present at birth but begin to appear toward the end of the first year or during the second. They spring from the level of the anterior part of the ethmoidal labyrinth, and enlarge progressively upwards and from within outwards. When the sinuses are small they can be distinguished from the neighboring ethmoidal cells only by the fact that they are found between the two layers of the frontal bone. Further, the sinuses open indifferently into the two grooves at the top of the middle meatus, into which the ethmoid cells open, and the ethmoidal cells often mound into the floor of the sinus. Finally, upon the whole length of the ethmoidal notch of the frontal bone there is a row of little half cells which is matched and completed by a similar row of cells upon the upper surface of the lateral mass of the ethmoid bone.

The Size of the Sinus. According to certain writers it is possible to estimate the size of the sinus by the prominence of the superciliary ridge. Roughly this is true. It is owing to the size of the sinus and to its extension under the root of the nose that the brow of a man does not slope backward so much as that of a woman. The face of a child resembles the face of a woman in this respect because the sinus does not begin to develop until after birth and does not reach its full size until between twenty and twenty-five years. Defective development of the sinus is a characteristic of certain negro tribes. At eight years of age the sinus measures 6-7mm (¼in.) The average capacity of the sinus ranges between 4-5cc (1-1½ drachms.) Owing to more or less deviation of the septum which divides the sinuses they are seldom of the same size.

The Mucous Membrane of the Sinus. The mucous membrane is a derivative of the mucous membrane of the nose and has the same extensive vascular and nerve supply. The mucous membrane of the nasal fossa consists of two kinds, the respiratory and the olfactory. The mucous membrane of the respiratory region is distinguished from that of the olfactory region by its thickness (4mm) and by the presence of a venous network of large size. The epithelium is ciliated and of the stratified columnar type. Within its superficial layer there are numerous goblet cells. The tunica propria is composed of fibrous connective tissue containing many clefts occupied by leucocytes. Occasional nodules of lymphoid tissue are scattered through this. The mucous membrane contains numerous racemose glands which open on the free surface by funnel like pits. They are mixed glands, some of which secrete serous fluids, some mucous

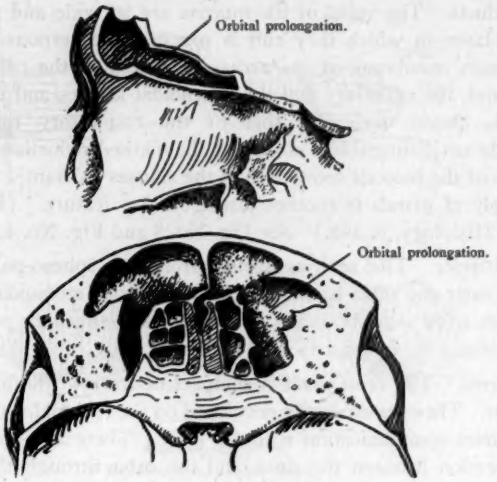


Fig. No. 5.—Sieur and Jacob.
The backward or orbital prolongation.

Fig. No. 6.
Prolongation of the frontal sinus into the crista galli.

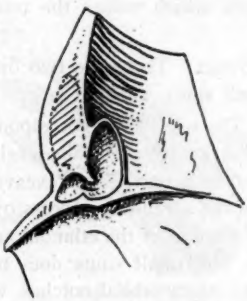


Fig. No. 7.—Sieur and Jacob.
Prolongation into the crista galli and into the root of the nasal bone.

products. The veins of the mucosa are so wide and plentiful that the layer in which they run is practically cavernous tissue. The mucous membrane of the accessory spaces of the nasal fossa, the frontal, the maxillary and the sphenoidal sinuses and the ethmoidal cells, closely resembles that of the respiratory region. These tracts are distinguished chiefly by the marked reduction in the thickness of the mucous membrane of the sinuses (.02mm). The meagre supply of glands is another distinguishing feature. (Piersol, Normal Histology, p. 402.) See Fig. No. 3 and Fig. No. 4.

Arteries. The arteries spring from the spheno-palatine artery and enter the sinus by its duct. The anterior ethmoidal artery furnishes a few small branches which enter sometimes the posterior face, sometimes the inferior face.

Veins. The veins make a compact network in the mucous membrane. They are especially developed on the external wall. They are in direct communication with the orbit. There is a second venous connection between the sinus and the orbit through the ethmoidal veins. These pierce the posterior and the inferior wall. The veins of the posterior or the cranial wall come into relationship with the superior longitudinal sinus or better with the vein of the foramen cæcum. The greater part of the venous blood naturally empties into the spheno-palatine vein, the vein which collects the blood from the mucous membrane of the turbinates and the regions between.

Lymphatics. The lymphatics are a part of the lymphatic system of the nose. They are, therefore, in relation, the same as the lymphatics of the nose, with the sub-arachnoid space by means of minute bony canals in the walls of the sinus.

Nerves. The nerves of the frontal sinus come from the ethmoidal branch of the nasal nerve. The nerves are very numerous and are arranged in a network which makes the mucous membrane very sensitive.

The Form of the Sinus. There are two distinct varieties of the frontal sinus, the small sinus, and the large.

The Small Sinus. The small sinus corresponds to the rounded excavation which is ordinarily present at the level of the inner angle of the orbit at its fronto-orbital part. This excavation is placed behind the posterior border of the ascending process of the superior maxilla and in front of the os planum of the ethmoid and immediately above the lachrymal bone. The small sinus does not rise above a line drawn between the two supra orbital notches, while its anterior border is limited by a line running up from the crest of the lachrymal

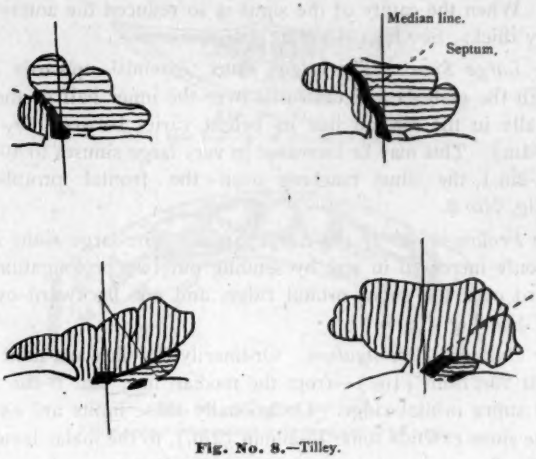


Fig. No. 8.—Tilley.
Deviation of the median septum.

Fig. No. 9.
Figure showing partial septa at the summit of the sinus parallel with the median septum. Diagrammatic.

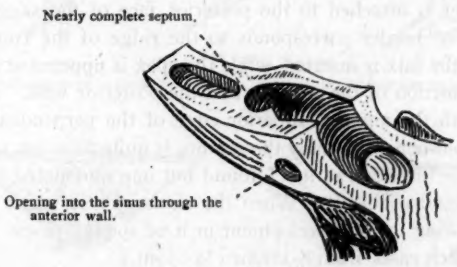


Fig. No. 10.
Large septum nearly dividing the sinus into two parts. An opening through the anterior wall in the position indicated in the drawing would lead the operator to think that the septum was the outer wall of the sinus.

bone. When the cavity of the sinus is so reduced the anterior wall is very thick. See Fig. No. 22.

The Large Sinus. The large sinus extends upwards nearly through the glabella and outwards over the inner half of the orbit. Normally in the median line its height varies between 20—25mm (¾in-1in). This may be increased in very large sinuses to 40-50mm 1½in.-2in.), the sinus reaching even the frontal protuberence. See Fig. No. 2.

The Prolongations of the Large Sinus. The large sinus is very commonly increased in size by sending out two prolongations, one outward over the supra orbital ridge, and one backward over the orbit. See Fig. No. 5.

The Outward Prolongation. Ordinarily the outward limit of the sinus is 25-27mm (1in.)—from the median line, that is the middle of the supra orbital ridge. Occasionally these limits are exceeded and the sinus extends some 45-50mm (2in.), to the malar bone. See Fig. No. 2

The Backward Prolongation. The backward prolongation extends backward on the inner side of the sinus to end blindly about 15-10mm (⅝in.), from the rim of the orbit. The height of the prolongation is scarcely 2-3mm (⅛in.) It comes into direct relation with the anterior ethmoid cells. See Fig. No. 5.

Two other small prolongations of the sinus are sometimes found; a prolongation into the crista galli and a prolongation into the root of the nasal bone. See Fig. No. 6 and Fig. No. 7.

The cavity of the frontal sinus is frequently narrowed by the ethmoid cells mounding into it. The relationship of the ethmoid cells will be discussed in speaking of the floor of the sinus.

The Septum of the Sinus. Normally the septum of the sinus is a triangular plate of bone placed vertically between the two sinuses. Its anterior border is attached to the posterior face of the saggital suture, its posterior border corresponds to the ridge of the frontal bone upon which the falx is inserted, while the apex is uppermost and is placed at the junction of the anterior and the posterior wall. The base is joined with the anterior superior edge of the perpendicular plate of the ethmoid bone. Usually the septum is quite thin, but only rarely are there perforations in it. I found but one undoubted perforation in one hundred heads. When the sinus is very small the septum is thick owing to the development in it of spongy tissue. It may measure in such cases from 6-12mm (¼- ½in.)

The deviations of the septum are extremely variable. They have been figured and described by Tilley. See Fig. No. 8. On account

Fig. No. 11.
Rib of bone guarding the opening of the sinus.

Fig. No. 12.—Sieur and Jacob.
Partial septa making pockets in the upper part of the sinus.

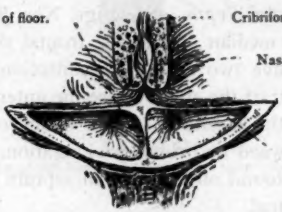


Fig. No. 13.
The divisions of the floor of the sinus.

Fig. No. 14.
The two forms of the floor of the sinus, the funnel-shaped floor and the saucer-shaped floor.

(1) **Fig. No. 15.** (2)

1. Transverse section of the funnel-shaped sinus. 2. Transverse section showing a step jutting out from the median septum.

of its surgical bearing, it is important to remember that no matter how much deviated the upper part of the septum may be the base is nearly always in the median line. Owing to these deviations the danger of opening the sinus of the opposite side has to be borne in mind. Three times in twenty subjects Sieur and Jacob found the sinus of one side encroaching on that of the other. Twice this encroachment amounted to 10mm (⅜in.) and once to 5mm (⅛in.) Exploring the sinus by the naso-frontal route in the first two cases would have resulted in opening the sinus of the opposite side, in the other case both sinuses would have been opened. I have not found in the examination of my specimens that the sinus of one side so frequently crosses the middle line as the figures just given would seem to indicate. Sieur and Jacob give the figures at 17%. I should place the percentage much lower, something like three to five per cent. Nevertheless, the fact that this does occur is important in the applied anatomy of the sinus. Naturally, therefore, the sinus should be entered from as low a point as possible.

Incomplete or Partial Septa. See Figs. Nos. 9, 10, 11, 12.

In addition to the median septum the frontal sinus often has partial septa. These have two seats of predilection. The commonest place is at the summit of the sinus where the anterior and the posterior walls meet, and the second and more dangerous place is the beginning of the backward or orbital prolongation. Rarer and more accessible septa are found on the median septum itself. These are usually roughly vertical.

The septa which occur in the summit of the sinus run parallel with the median septum, so that the pockets which they make empty freely into the lower part of the main sinus. Where, however, they run obliquely, the reverse of this is true. The thickness of these septa scarely exceeds 1-2mm, that is, they are about as thick as stout paper. Their size depends upon the distance between the two tables of the frontal. Their height varies between 5-10mm (⅛-¼in.) I found these small septa in about 10% of the cases. In about 1 or 2 % of the cases there occurs a very large septum which almost divides the sinus into two parts. See Fig. No. 10. At first sight it seems as if the sinus is completely divided, but just at the lower posterior angle of such a partition there is always a communication with the main sinus. One could readily mistake such a partition for the outer wall of the sinus unless he had this point in mind and passed a probe round the lower end of the partition into the part of the sinus beyond.

The partial septa of the backward prolongation of the sinus are easier to get at than those of the upper part. Usually there are not

Fig. No. 16.
Sinus with right angular ledge projecting from the median septum.

Fig. No. 17.
Sinus with projecting ledge from the median septum under which runs the anterior ethmoidal artery.

Fig. No. 18.
Sinus similar to No. 17 seen from above.

Fig. No. 19.
Funnel-shaped sinus.

more than two or three of these. The greatest number recorded is four. These septa have a tendency to cross the axis of the prolongation obliquely, not to run parallel with it. For this reason the pockets which they make drain very poorly.

The study of the relations of the sinus is the study of the sides which compose it. There are three such sides or faces, and the naso-frontal canal which connects the frontal cavity with the nasal cavity.

The Anterior or Frontal wall.

The anterior wall, when it exists, is subcutaneous in its whole extent. Exploring the sinus through this wall would be most easy if it were not for its thickness and the great variability of the size of the sinus.

Limits of the Anterior wall.

Where the development of the sinus is normal the anterior wall begins below at the naso-frontal suture and ends in the median line half way to the frontal protuberance. On the sides it extends to the mid point of the orbital rim. Taking subjects as they run on the dissecting table the absence of the anterior wall occurs more frequently than writers usually state. Sixty-nine sinuses in thirty-seven subjects were examined with care on this point. (Sieur and Jacob). Twenty-two sinuses (31.8%) were limited to the superior internal angle of the orbit and had no connection with the anterior wall. Forty-seven sinuses had more or less relationship with the anterior wall and all corresponded to that part of the naso-frontal eminence which is just behind the root of the nose. The area to which the forty-seven correspond is an irregular trapezium bounded within by the medio-frontal suture, below by the naso-frontal suture, and above by a line between the two supra orbital notches. This space corresponds in two-thirds of the cases to the cavity of the sinus. It cannot be accepted unreservedly, however, because once in three cases the sinus does not reach so far forward. This space occupies a very low position so that if one has reason to think that there is a good sized sinus it is the point of election for approaching the sinus from the anterior or frontal face. In approaching the sinus from this point it must be remembered that occasionally the sinus of the opposite side will be opened.

The average thickness of the anterior wall is 4mm (⅛in. +). It may be as little as 1-2mm or as great as 7-12mm (1-32-½in.)

Structure of the Anterior Wall. The anterior wall is ordinarily compact at the orbital rim. For the rest of its extent it is made up of spongy tissue, especially at the frontal protuberances. This

Fig. No. 20.
Saucer-shaped sinus.

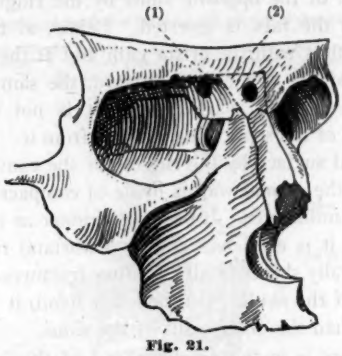


Fig. 21.
1. Region where the sinus, however small, can always be opened. 2. Region where the sinus can be opened in two-thirds of the cases.

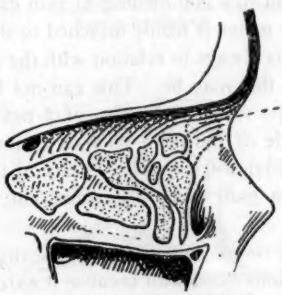


Fig. No. 22.—Sieur and Jacob.
Frontal Sinus reduced to the size of an anterior ethmoid cell.

layer of spongy tissue is what gives the free bleeding when the sinus is entered from the anterior wall. Owing to many small channels in the bone this wall is in relation with the external circulation. By means of these infection can travel both inward and outward. The anterior wall often ends superiorly in a set of cells which rim it about like a crown. These cells occasionally require opening up after the fashion of the cells of the mastoid process.

The Posterior or Cranial Wall. The posterior wall corresponds to the cavity of the cranium. This wall is made up of two parts, a vertical part and a horizontal part. The horizontal part is the roof of the backward or orbital prolongation. See Fig. No. 5.

In the median line and above, the posterior wall is separated from the posterior wall of the opposite sinus by the ridge of the frontal bone upon which the falx is inserted. Below, at the level of the orbit, this wall unites with the crista galli and at the sides joins the cribriform plate of the ethmoid. Outward, the same as above and below it is not especially marked off. It is not smooth on the sinus side because of the septa which spring from it. It is roughened on its intra cranial surface by the ridges for the convolutions of the brain. Although the cranial wall is made of compact bone its thickness is barely one millimeter. It becomes thinner as it runs forward so that anteriorly it is even less able to withstand trauma, and on that account generally shares in all radiating fractures of the anterior part of the base of the skull. On the other hand, it is more out of the reach of pus than the other walls of the sinus.

Fairly often there is in the neighborhood of the foramen cæcum a bony canal, running to the cranial cavity and emptying into the frontal sinus. Normally there are openings in the internal wall at the level of the frontal proturberences which give passage to veins which finally end in a sub meningeal vein of considerable size. At this level the dura mater is firmly attached to the bony wall.

The posterior wall is always in relation with the cavity of the sinus no matter how small this may be. This can not be said of the anterior wall. When the sinus is the size of a pea and occupies the superior internal angle of the orbit its roof is formed by the bone anterior to the ethmoidal notch and the cavity of the sinus is placed just outside the crista galli and the termination of the cribriform plate.

The Floor of the Frontal Sinus. Anatomically the floor of the frontal sinus is the orbito-nasal wall because it extends over the roof of the nasal fossa and over the inner part of the anterior portion of the orbit. (See Fig. 13.) The floor is either funnel shaped or

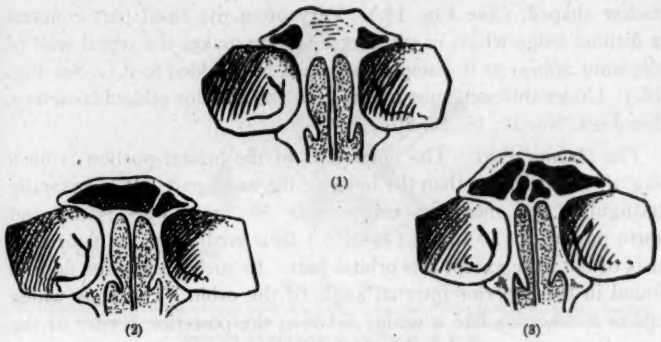


Fig. No. 23.—Sieur and Jacob.

The relationship of the floor of the sinus with the roof of the nasal fossa.

1. Nasal roof not in relation with the sinus. 2. The right frontal sinus in relation with the nasal fossa of both sides. 3. Anterior ethmoidal cells intervening between the floor of the sinus and the roof of the nose.

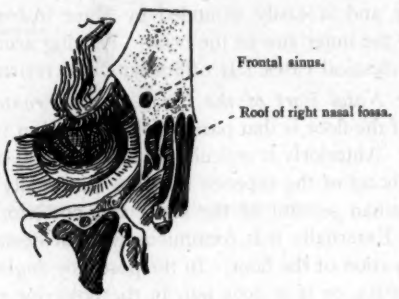


Fig. No. 24.

Frontal sinus small and not in relation with the roof of the nasal fossa. Sinus ¼-in. (7 mm) from the median line.

Fig. No. 25.

The same specimen as Fig. No. 24 seen from the side. Thickness of the frontal wall at the root of the nose ⅞-in. (22 mm.)

saucer shaped. (See Fig. 14.) Very often the nasal part contains a distinct ledge which in transverse section makes the septal wall of the sinus appear as if a step of bone had been added to it. (See Fig. 16.) Under this step runs a branch of the anterior ethmoidal artery. See Figs. No. 17, 18, 19, 20.

The Orbital Part. The outer part of the orbital portion is on a slightly higher plane than the inner or the nasal part. It is generally triangular, and measures transversely 15-29mm (⅝-1⅛in.) and antro posteriorly 10-15mm (⅜-⅝in.) In a small sinus the floor consists of but little except this orbital part. In such a sinus the floor is found in the superior internal angle of the orbit. The bone which makes it descends like a wedge between the posterior border of the ascending process of the superior maxilla and the os planum of the ethmoid. Below it articulates with the lachrymal bone. Measuring from the lachrymal bone its height is 12-20mm (½-¾in.) Its width is less extensive, varying between 12-15mm (½-⅝in.) The bone is so thin that it has been broken by a scratch. (See Fig. 21.) It participates in all fractures at its level which run to the orbital border and is easily wounded by blunt instruments if they strike under the inner rim of the orbit. Fencing accidents have furnished some classical cases. It offers but little resistence to pus.

The Nasal Part of the Floor of the Frontal Sinus. The nasal part of the floor is that part which is placed in front of the ethmoidal notch. Anteriorly it articulates with the nasal bones and the ascending process of the superior maxilla. Internally it is in relation with the median septum of the sinus and posteriorly with the ethmoid cells. Externally it is continuous without demarkation with the orbital portion of the floor. In the posterior angle of this quadrilateral if it exists, or if it does not, in the posterior part of the floor and the width of half the ethmoidal notch from the median septum, there is an opening which connects the sinus with the middle meatus of the nose. In the smallest sinuses the floor as such ceases to exist and the cavity of the sinus is pushed outward into the superior internal angle of the orbit and appears simply as an anterior ethmoid cell, which developmentally it is.

The under surface of the nasal part corresponds internally with the roof of the nasal fossa and externally rests upon the ethmoid cells at the summit of the middle meatus. The relation of the floor of the frontal sinus to the nasal vault is very variable. Sometimes the floor of the sinus is directly over the roof of the nose; oftener it is not. In sinuses of a median calibre the floor may be reduced to a slit which crosses the nasal fossa only very slightly. As has just

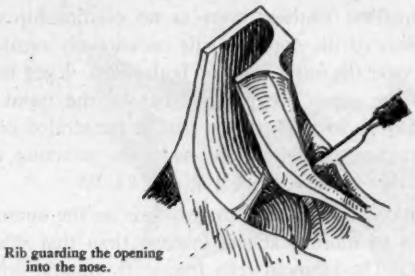


Fig. No. 26.

Prolongation forward of the ethmoid plate in a finger-like process. The point of the knife is inserted into this and is seen through the outer wall of the prolongation. This prolongation is in the posterior internal angle of the floor of the sinus.

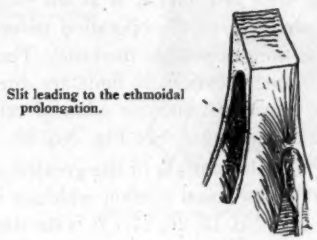


Fig. No. 27.

The forward prolongation of the ethmoid plate seen from above.

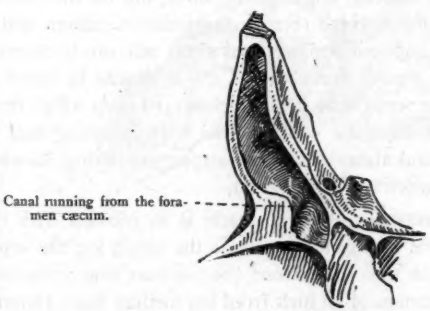


Fig. No. 28.

A marked canal for the vein of the foramen cæcum. This canal mounds into the postero-internal angle of the sinus.

been said, in the smallest sinuses, there is no relationship at all. Furthermore, the sinus of the opposite side occasionally crosses the median line and lies over the nasal fossa on both sides. Even in cases where the floor of the sinus occupies 5-8mm of the nasal vault (¼ in.) the bone may be so thick that it can be penetrated only by a drill. These anatomical considerations make the puncture of the floor of the sinus rarely feasible. See Fig. 23, 24, 25.

The part of the nasal floor which corresponds to the summit of the middle meatus is of more practical interest than that which is over the nasal fossa. The ethmoid cells frequently mound into this and narrow the cavity of the sinus or make drainage by the natural opening into the nose difficult. It is common to have one of these cells attain a considerable size and project into the sinus, especially posteriorly. Such a cell is often called the frontal bulla. When catheterization of the sinus is successful the catheter generally forces its way through some such cell, and it is at the expense of such cells that drainage is obtained in the operation of enlarging the naso-frontal duct from the sinus down into the nose. The sizable openings into the sinus which one occasionally finds are due probably to the breaking down of some such anterior ethmoid cell which was in relation with the floor of the sinus. See Fig. No. 35.

The posterior internal angle of the sinus is of the greatest surgical importance. This is the part of the nasal portion which is in front of the ethmoidal notch. See Fig. No. 13, 26, 27. It is the dangerous area of the sinus. Nature seems to recognize this because there is often a small rib of bone running diagonally downward and outward which protects this region. The ethmoid plate often sends forward here a finger like process which invites accidents. See Fig. No. 26. Also, in this posterior internal angle of the sinus, but on the median septum, however, the vein which runs in the foramen cæcum and is the beginning of the superior longitudinal sinus not rarely mounds into the cavity of the sinus. See Fig. No. 28. It should be borne in mind in exploring the sinus that it is necessary to keep away from the median septum at least the width of the corresponding half of the ethmoidal notch, and always to do the strong curretting forward and outward, never backward and inward.

The pulley of the superior oblique muscle is in relation with the floor of the sinus. The best guide to this is the notch for the supra orbital nerve. This is one inch from the median line. (25mm). The pulley is three-quarters of an inch from the median line (18mm), one-quarter of an inch nearer the median line than the notch and one-quarter of an inch (6mm) below it. In the wet speci-

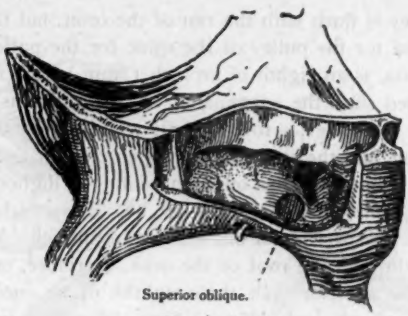


Fig. No. 29.
The attachment of the superior oblique muscle.

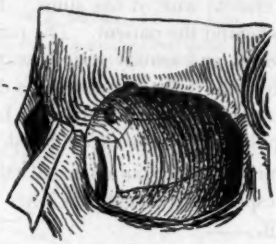


Fig. No. 30.
The fossa for the attachment of the superior oblique.

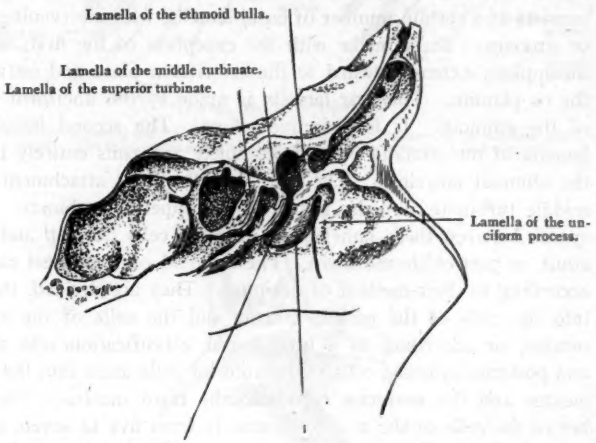
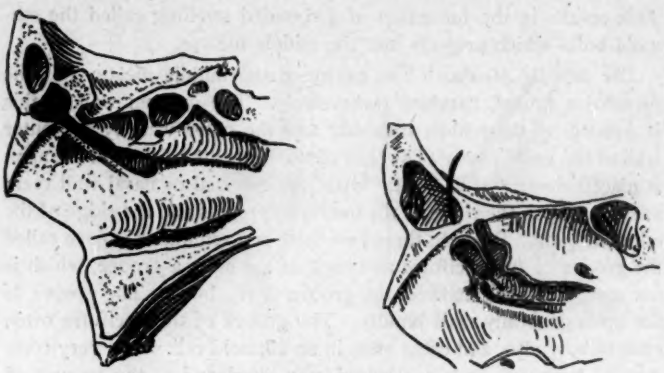

Lamella of the ethmoid bulla.
Lamella of the middle turbinate.
Lamella of the superior turbinate.
Lamella of the unciform process.
Groove of the ethmoid bulla.
Hiatus semilunaris or groove of the unciform process.

Fig. No. 31.—Hajek.
Figure showing the basal lamellæ of the ethmoid labyrinth.

men the pulley is flush with the rim of the orbit, but in the cleaned skull the fossa for the pulley or the spine for the pulley, if this replaces the fossa, is an eighth of an inch (3mm.) back from the rim. On the cleaned skull the examination of 50 specimens showed that the fossa for the pulley is roughly half way between the top of the lachrymal bone and the supra orbital notch, and that the lower part of the fossa of the pulley is on a line with the highest part of the naso-frontal suture. See Figs. No. 29, 30. The attachment for the pulley occupies a space about one-quarter of an inch (6mm) square. In breaking through the roof of the orbit, therefore, one should go back from the anterior wall three-eighths of an inch (1cc) and should be at least one inch (25mm) from the median line. In order to get far enough away from the anterior wall one must keep close to the posterior or cranial wall of the sinus. This is easier to do if the operator stands behind the patient. The pulley is attached to the periosteum of the orbit and readily strips away with it. It is well, therefore, to consider that if the periosteum is disturbed at all within the orbital rim that the pulley is disturbed. In opening a sinus of the small type the pulley is always encountered.

As the frontal sinus is simply an enlarged ethmoid cell the rest of the ethmoid cells, especially the anterior ones have very important relationships with it.

The scheme of the ethmoid region given by Hajek (See Fig. No. 31) is the simplest and the most practical. The ethmoid labyrinth consists of a certain number of basal lamellæ with intervening spaces or grooves. The lamellæ with the exception of the first, which is incomplete, extend upward to the cribriform plate and outward to the os planum. The first lamella is made by the unciform process of the ethmoid. It is defective above. The second lamella, the lamella of the ethmoid bulla, is complete and runs entirely through the ethmoid labyrinth. The third lamella gives attachment to the middle turbinate, and the fourth to the superior turbinate. In the spaces between these lamellæ the ethmoid cells develop and in the adult, in part obliterate them. The ethmoid cells are best classified according to their method of draining. They are divided, therefore into the cells of the middle meatus and the cells of the superior meatus, or according to a little looser classification into anterior and posterior ethmoid cells. The anterior cells drain into the middle meatus and the posterior cells into the third meatus. The number of the cells of the middle meatus is from five to seven, and the number of the cells of the third meatus is three to five. One or two ethmoid cells are generally developed in the lamella of the bulla.



(1) (2)

Fig. No. 32.—Sieur and Jacob.

1. Frontal sinus opening directly into the groove of the unciform. No naso-frontal canal.
2. Marked naso-frontal canal.

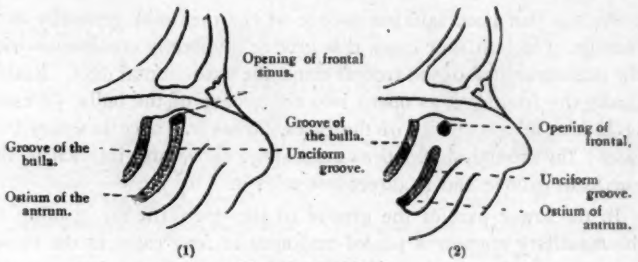


Fig. No. 33.—Hajek.

1. Frontal sinus opening into the groove of the unciform. 2. The groove of the unciform ends blindly. The frontal sinus opens just above the unciform groove and in line with it.

Fig. No. 34.—Sieur and Jacob.

An anterior ethmoidal cell mounding into the floor of the frontal. Probe punch through this into the sinus. The posterior arrow enters the sinus through the ostium.

This results in the formation of a rounded swelling called the ethmoid bulla which projects into the middle meatus.

The Middle Meatus. The cavity of the middle meatus has the form of a funnel, flattened transversely. The internal wall of this is formed by the middle turbinate and the outer wall by the outer wall of the nasal fossa. The base of the funnel is below and the apex is placed above and in front. Upon the external or nasal wall there are two ridges, the ridge of the unciform process and the ridge of the ethmoid bulla. Between these two there is a semilunar groove called the groove of the unciform and back of the bulla a groove, which is not always so well marked, the groove of the bulla. The groove of the bulla generally ends blindly. The groove of the unciform often ends blindly also, and often ends in an ethmoid cell. It is very common to have one or two ethmoid cells developed at the summit of this groove. These cells are in direct relation with the floor of the frontal sinus. Very often, as pointed out above, a cell in this position called the frontal bulla attains a considerable size and mounds into the floor of the sinus. See Figs. No. 32, 33, 34.

As has just been said the groove of the unciform generally ends blindly. Once in four cases this groove is directly continuous with the drainage canal of the frontal sinus, the naso-frontal duct. Rather rarely the frontal sinus opens into the groove of the bulla. (6 cases in 150.) In a majority of the cases, however, (once in every two cases) the frontal sinus opens separately, above and internal to the unciform groove and in direct line with it.

In the lower part of the groove of the unciform the opening of the maxillary antrum is placed and once in four cases in the upper part, the opening of the frontal and front and back of the groove like grapes from a central stem empty the majority of the anterior ethmoid cells. A few of these empty back of the bulla into the posterior part of the middle meatus. Another ethmoid cell, the cell of the agger nasi occasionally either mounds into the floor of the frontal sinus or projects backward and blocks the groove of the unciform, or as it is called in the older nomenclature, the hiatus semilunaris. In like manner any enlargement of the ethmoid bulla, especially any forward enlargement, also blocks this groove. The bulla, therefore, holds the key to the drainage of the frontal sinus, the maxillary sinus and most of the anterior ethmoid cells. As the anterior end of the middle turbinate hides the bulla, practically all exploring and all operating for sinus disease begins with the removal of the anterior end of the middle turbinate.

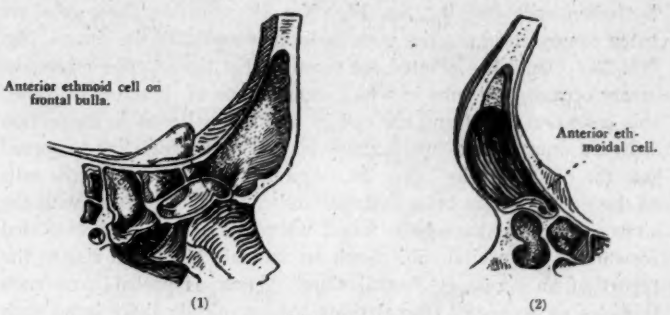


Fig. No. 35.

1. An anterior ethmoidal cell (frontal bulla) projecting into the floor of the sinus. 2. An anterior ethmoid cell opening into the sinus.

Fig. No. 36.—Onodi.

Anterior ethmoid cell opening into the sinus.

Fig. No. 37.

Cell of the groove of the bulla passing to the outside of the sinus and extending to the orbital rim.

Fig. No. 38.—Onodi.

Canal of the anterior ethmoidal artery open on the inner wall of an anterior ethmoid cell.

The anterior ethmoid cells of the upper part of the groove of the unciform not only often mound into the floor of the frontal sinus but often open into it. See Fig. No. 35. Further these cells are often connected in a series with each other and with the sinus. Fig. No. 36. Onodi has pointed out recently that the anterior ethmoidal artery occasionally runs in a half canal in one of these cells. When this condition exists and the cell in which this lies is in connection with the sinus there is another way opened up for infection to spread into the cranial cavity. No. 38. Again not rarely one of the cells of the groove of the bulla enlarges and comes into relation with the sinus. Instances have been found where such a cell has extended forward to the orbital rim. Such an anomaly has given rise to the report of an accessory frontal sinus. There is probably no such thing as an accessory frontal sinus. Anatomically there is no such thing as the absence of the sinus. It is always present as an ethmoid cell. See Fig. No. 37.

The Frontal Canal. The majority of writers describe in connection with the frontal sinus a canal which unites it with the middle meatus of the nose. Poirier makes this 15mm (1-2in) long in the male and 10mm (3-8in) in the female. Its form is cylindrical, but it is slightly compressed from side to side. The diameter varies between 2-3mm (1-16-⅛in.) It can be entered by bougies corresponding to numbers 6, 7, 8, 9, 10, of the French scale.

The canal cannot be isolated from the cul-de-sacs of the ethmoid cells which surround it and make it. When these are atrophied the duct does not exist and the sinus is in direct relation with the middle meatus. When the cells at the upper part of the middle meatus are well developed they mound into the cavity of the sinus and lengthen the duct. In one half of the cases a probe can be passed from the frontal sinus through its duct down into maxillary antrum. Pus, therefore, can find its way into the antrum in a still greater number of cases.

The Superior Opening of the Naso-Frontal Duct. See Fig. No. 39. The upper opening of the canal is placed the width of the corresponding half of the ethmoidal notch from the median septum of the sinus. Its form and dimensions may be those of the canal below or it may differ greatly from this. Ordinarily the opening is roughly oval. When the ethmoid cells mound into the floor of the sinus they modify its shape, but what is of greater importance, they interfere with the entrance of secretion into it. Fig. No. 40 gives marked examples of this. In one case the opening is placed over and behind the frontal bulla, in another behind and below it. Even when there

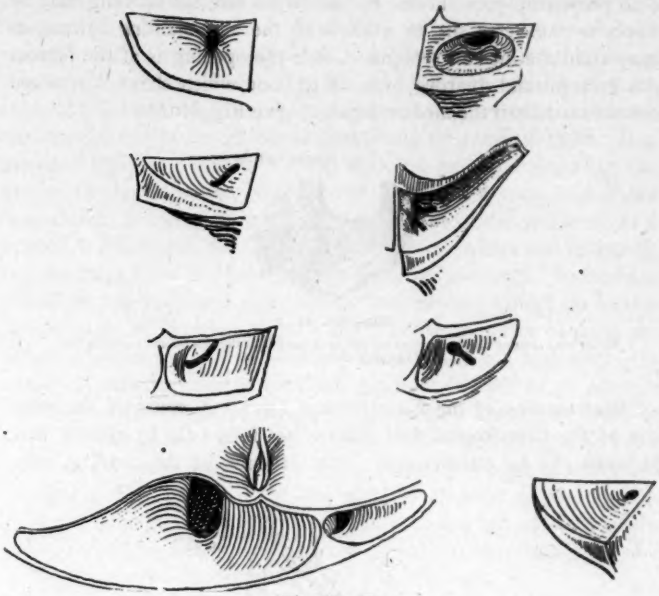


Fig. No. 39.

Different forms of the opening of the naso-frontal duct in the floor of the sinus. The next to the last drawing shows the extension of the right sinus beyond the middle line into the region of the left sinus. The opening of the right sinus into the nose, the largest found by the writer measured ¼ by ⅛ inch (6 m m—12 m m.)

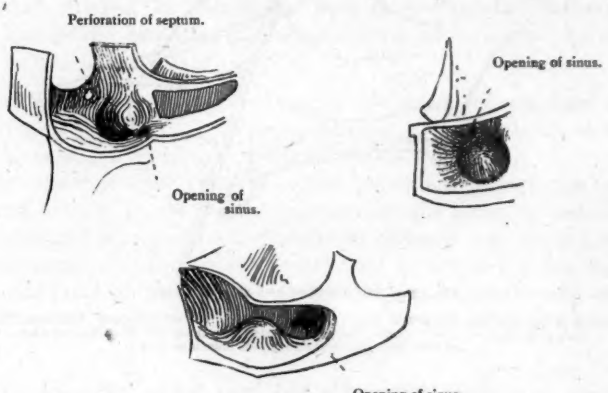


Fig. No. 40.

Examples of the frontal bulla mounding into the floor of the sinus.

is no projecting ethmoid cell to narrow its size the opening may be simply a transverse slit, or a slit with the axis slanting toward or away from the median septum. Often the opening is at the bottom of a deep pit and guarded by a rib of bone which slants downward and outward from the median septum. See Fig. No. 41.

Fig. No. 41.

Rib of bone running diagonally outward and downward from the septum and guarding the opening of the sinus.

Catheterization of the Naso-Frontal Duct. A study of the anatomy of the naso-frontal duct shows that it is only by chance that the sinus can be catheterized. The direction of the canal is very

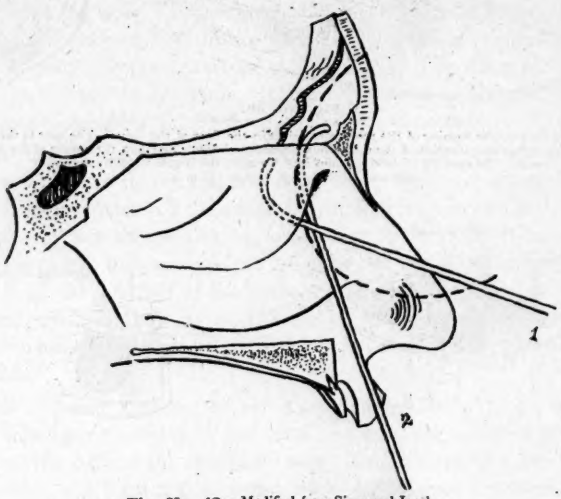


Fig. No. 42.—Modified from Sieur and Jacob.

Method of catheterizing the frontal sinus: 1. First position. 2. Final position. The dotted half circle gives the curve which a probe must have in order to come out the anterior nares when passed down from the sinus through the naso-frontal duct.

oblique from above downwards and from before backward. The opening of the duct is on the average 50mm (2in) away from the meatus.

In order to catheterize the sinus it is almost always necessary to remove the anterior end of the middle turbinate. Of course the meatus must be cleared of polypi. The procedure of catheterizing the sinus is as follows: See Fig. No. 42. The catheter is bent at an angle a little over or a little under 90 degrees, and introduced between the anterior end of the middle turbinate and the ethmoid bulla. It is then brought forward and rotated outward until it engages in the groove of the unciform. The handle is then depressed and if the naso-frontal duct is continuous with the groove of the unciform, as it is once in four cases, the catheter glides into the sinus and its handle falls backward and lies snugly against the incisor teeth. In case the groove of the unciform ends blindly the catheter brings up in this pocket or in an anterior ethmoid cell. In the majority of cases the catheter breaks through the base of this ethmoid cell and enters the sinus. If this does not happen and one finds himself in an anterior cell the catheter is withdrawn slightly, rotated inward in order to jump the bar at the top of the groove of the unciform and so enter the opening of the sinus which in one half of the cases is above and internal to this and in a direct line with it. In order to pass a probe from the sinus down into the middle meatus and out of the nose the probe should be bent to correspond to half or three-quarters of a circle two inches in diameter. See Fig. No. 42.

828 Beacon Street.

Clinical Studies in Deafness. Part II Analysis of Deafness Caused by Impacted Cerumen—OTSMANN—*Archiv f. Ohrenheilkunde,* Feb., 1904.

The author has devised a method of measuring the acuteness of hearing by means of calculations dependent upon the amplitude of the vibrations of specially constructed tuning-forks.

By means of these calculations the author has proven that the loss of hearing for the higher notes occasionally found in cases of deafness due to cerumen is not caused by pressure upon the ossicles or by a rise of labyrinthian pressure, but is due to the fact that the resonance of the external canal, which is harmonic with the higher notes, becomes obliterated when the canal is filled with cerumen.

YANKAUER.

THE SPHENOIDAL SINUS AND ITS SURGICAL RELATIONSHIP.*

BY H. HOLBROOK CURTIS, M. D.

The sphenoidal sinus has six walls which are important to study. First. The *superior* or *cranial wall* occupies the plane posterior to the cribriform plate of the ethmoid with which it articulates. The surface is continued laterally with the superior surface of the lesser wings of the sphenoid bone. At the posterior border of this flat bone there is a transverse groove which is hollowed out for the reception of the *optic commissure* and known as the *optic groove,* terminating in the optic foramina on either side, through which pass the optic nerves and the ophthalmic arteries. Behind this groove there is an eminence, the *olivary process.* Posterior to this the bone dips abruptly to make the *sella turcica,* which lodges the pituitary body. (Fig. I. pp. 857.)

In youthful subjects (under fifteen) the sinus may only extend to the vertical plane passing through the optic groove, but in the adult the sinus may develop antero-posteriorly to the extent of 20 to 30 millimeters.

The superior wall for convenience is divided in an olfactory area, (for the olfactory nerves traverse it on either side of the longitudinal eminence) an optic area, and the area of the sella turcica.

This superior wall, however, is oftentimes not in relation to the entire sinus, for frequently the septum arises so far to one side that only one chamber of the sinus is in relation to it. Again, a posterior ethmoid cell may insinuate itself between the sinus and its superior cranical wall. In composition the superior wall may be very hard and thin or, on the other hand, be composed of diploic bone. The portion comprising the sella turcica, however, is apt to be delicate and friable and especially liable to accidents of instrumentation. This possibility should be guarded against in penetrating the anterior wall, for we never know how near the sella turcica may be to the point of entrance. The proximity of the dura mater to this wall accounts for the frequency of cerebral pain as a symptom of sphenoidal inflammation, and for the distressing symptoms which

* Read before the ninth annual meeting of the American Larnyngological, Rhinological and Otological Society, held at Chicago, June 1st, 1904.

have been reported as having followed simple irrigation of the sinus. Schech has reported unconsciousness to have followed such a lavage with glycosuria and polyuria as symptoms. (250 oz. in 24 hours).*

While perforations of the sella turcica may cause abscess and inflammation of the pituitary body, conversely we find that in acromegaly the sinus is sometimes affected by a process secondary to the involvement of the pituitary body, with consequent perforation of the sella turcica.

Second. *The external walls* for two-thirds of their extent posteriorly constitute the dipping sides of the sella turcica. They are limited below by the common root of the great wings and the pterygoid processes. These walls are longitudinally grooved in their superior half for the reception of the cavernous sinuses, Fig. I. 14. These

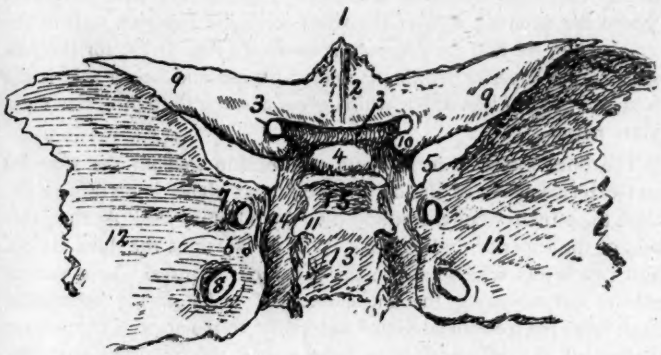


Fig. I. The Superior and Posterior Walls of the Sphenoidal Sinus.

1. The ethmoid spine which articulates with the cribriform plate. 2. Eminence, with grooves each side for olfactory nerves. 3. Optic groove terminating in optic foramen, for optic nerve and ophthalmic artery. 4. Olivary process. 5. Sphenoidal fissure. (Foramen lacerum anterius) which transmits 3d, 4th, 5th and 1st division (ophthalmic branches) of 5th nerves, the ophthalmic vein, a recurrent branch from the lachrymal artery and the orbital branch of the middle meningeal artery. 6. Foramen vesali 7. Foramen rotundum for passage of 2nd division of 5th nerve, (superior maxillary). 8. Foramen ovale for 3rd division of 5th nerve, (inferior maxillary), the small meningeal artery and the small petrosal nerve. 9. The lesser wings. 10 Anterior clinoid process. 11. Posterior clinoid process. 12. The greater wings. 13. The dorsum sellæ continuous below with the basilar groove supporting the pons varolii and medulla oblongata. 14. Cavernous groove. 15. Sella turcica.

grooves become vertical posteriorly to receive the internal carotid arteries, and anteriorly they dip down and form the internal limit of the sphenoidal fissure. Immediately anterior and superior to the cavernous grooves the anterior third of the walls is hollowed out to make with the two roots of the anterior clinoid processes and the

* *Berl. klin. Wchnschr.*, June 27, 1898.

lesser wings of the sphenoid bone, the foramina for the passage of the optic nerves and ophthalmic arteries.

The optic nerves pass over the superior surface and dip down to occupy a portion of the anterior upper surface of the external walls, then they make exit from the optic foramina, being on a plane immediately posterior to the suture uniting the os planum with the anterior wall of the sphenoid. Beside the optic nerves, which lie in such close relationship to the sphenoidal walls, the cavernous sinus is the conduit of the sixth, the third, the fourth, and the ophthalmic division of the fifth nerves, in their route to the orbit. The internal carotid artery passing through the cavernous sinus lies in proximity to the walls of the sphenoidal sinus, and the sixth nerve lies on its outer side; the other above mentioned nerves occupy the outer wall of the cavernous sinuses. Under the cavernous groove anteriorly where the external wall of the sinus joins the superior wall of the great wing, we find the *foramen rotundum* (Fig. 1. 7), for the passage of the superior maxillary nerve; behind and below this is the foramen ovale, (Fig. 1. 8), which gives passage to the inferior maxillary nerve.

The dura mater is in intimate relationship to both the superior and external walls of the sphenoidal sinus: above it divides to enclose the pituitary body, forming thus the pituitary sac. At the junction of the superior and external walls of the sinus the dura divides into two layers which enclose the cavernous sinuses. These venous sinuses extend along the entire external walls of the sphenoidal sinus from the sphenoidal fissure anteriorly, to the apex of the petrous portion of the temporal bone, where they communicate with the lateral sinuses by the superior and inferior petrosals. The sinuses communicate with each other by the transverse sinus posteriorly, and anteriorly by the circular sinus, which surrounds the pituitary body. The ophthalmic vein leads from the angular vein at the inner angle of the orbit and empties into the cavernous sinus at its anterior extremity, an important fact to remember from a surgical standpoint. In this manner the orbito-nasal circulation is in connection with the intra-cranial venous system. The posterior wall of the sinus (Fig. 1. 13), inclines downwards and backwards, losing itself in the basilar process of the occipital. The surface immediately posterior and below the posterior clinoidal processes is traversed by the transverse sinus, which unites the cavernous sinuses of either side. The dura mater, which lines the basilar groove, and the spinal meninges here unite to envelope the transverse sinus. In the median line runs the basilar artery, while the surface on either side is grooved for the

motor osculi, (3rd), the patheticus, (4th), the abducens, (6th), and the ophthalmic (1st Div. of 5th) nerves. Immediately behind this wall of the sinus lies the medulla oblongata.

It is not difficult to understand, when we consider the intimate relationship both vascular and nervous, how inflammations and empyemas of the sinus are wont to set up a train of nervous symptoms and cephalgias most valuable in diagnosis, and this before the patient has reached a state when paralysis and infection of the circulation manifest themselves.

Very often we find the posterior inferior angle of the sphenoid sinus extending down into the occipital bone, and only separated from the medulla by a thin lamina of bone forming the basilar groove. Sometimes the transverse sinus is so intimately in connec-

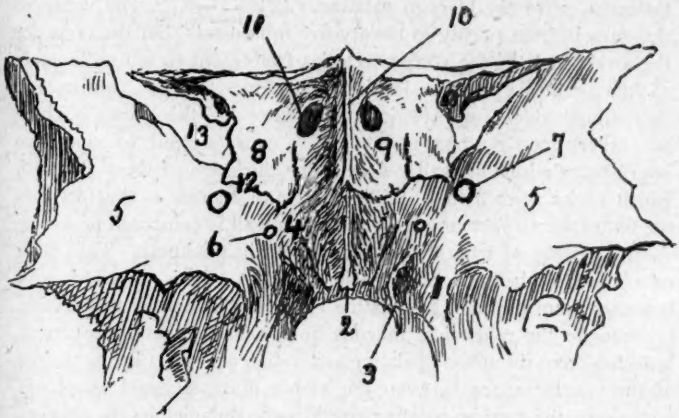


Fig. II. The Inferior and Anterior Walls of the Sphenoidal Sinus.

1. Root of pterygoid apophysis. 2. Crest for articulation with vomer. 3. Pterygo-palatine canal, made by articulation of inferior surface and palate bone. 4. Crest for articulation of wings of vomer, lateral limit. 5. Greater wings of sphenoid bone, orbital surface. 6. Vidian canal. 7. Foramen rotundum. 8. Area abutting ethmoid cells. 9. Nasal area of anterior wall. 10. Crest for articulation with perpendicular plate of ethmoid bone. 11. Orifice of sphenoidal sinus opening into sphenoidal recess. 12. Region of Sieur's cell between maxillary antrum and sphenoidal sinus. 13. Sphenoidal fissure.

tion with the spongy tissue under the sella turcica and posterior clinoid processes that dissection is difficult, and one easily recognizes the facility with which a thrombosis of the transverse sinus may arise from a sphenoidal sinusitis. Such a thrombus may cause a secondary affection in the circular and cavernous as well as the petrosal sinuses of both sides. The cerebellum lies outside and behind the medulla, attached by prolongations from the tentorium cerebelli to both the

anterior and posterior clinoid processes. For this reason we may account for the train of nervous symptoms which we are apt to observe in the initial stages of a sphenoidal sinusitis.

From the anatomical relationships already described we know why we are first suspicious of a sphenoidal sinusitis by the occipital cephalgia, disturbances of vision, vertigo, and nausea. These conditions may be followed by the various paralyses of the cranial nerves, alterations in the retina, the meninges, or in the brain tissue itself.

Before digressing too far from the anatomy, let us glance at *the inferior wall.* This is limited laterally by the pterygoid apophyses and presents a longitudinal crest in the center which articulates with the vomer; this crest terminates by a prominence in front called the rostrum. (Fig. II. 2). On either side of this crest and made by its articulation with the sphenoidal apophysis of the palate bone is a little canal called the pterygo palatine. (Fig. II. 3). The width of this face is from twenty to twenty-five millimeters, but the crest for the articulation of the vomer occupies from eight to ten millimeters of the central portion, leaving but four to five millimeters on either side for surgical entrance to the sinus. There are other good reasons to prevent a consideration of operative interference with this wall: One is the thickness of the wall itself, which varies from 3 to 10 millimeters, and another is the fact that the fibro-mucous membrane covering this wall is composed of a very vascular tissue of from 3 to 4 millimeters in thickness. This thick membrane is the seat of adenoid growths. It is supplied with branches from the pterygo-palatine arteries, which send perforating branches to the sphenoidal mucous linings, as well as by recurrent branches from the spheno palatine and vidian arteries. In the middle of the narrow space between the vomer and pterygoid apophysis posteriorly, the pterygo-palatine artery is accompanied by the pharyngeal nerve of Bock. These are both endangered in entering this wall surgically. The inferior wall of the sinus viewed from within bears no relationship to the external surface, for the dimensions may extend laterally into the great wings between the two compact layers which make up their walls. Sometimes this may amount to an extension of the sinus of from 12 to 17 millimeters on either side. In an antero-posterior direction the inferior face may extend to 30 millimeters; especially this may be the case in a large sinus where the cavity intrudes the basilar apophysis of the occipital. In considering the anatomical relations of the inferior, or pharyngeal wall, we must bear in mind that the pterygoid apophyses which limit it laterally, are only separated from one another by some 20 millimeters, and that directly back of them is the sphenoidal fissure at the

cranial end of which the internal carotid takes a trend upward emerging from the cavernous sinus. This artery has been injured by an instrument injudiciously applied to the inferior wall, with an almost fatal hemorrhage as a consequence, which necessitated the ligation of the internal carotid in the neck. It is also to be remembered that the vidian nerve and artery emerge from the vidian canal, (Fig. II. 6), which may be sometimes found internal to the root of the apophysis and have its position much nearer the median line than in normal cases.

Hajek has epitomized the objections to an entrance to the sinus by this wall, as follows:

First. A curved instrument must be employed, which is always less preferable than a straight tool.

Second. The wall is thicker than the nasal wall.

Third. In case of encountering a small sinus the basilar process may be penetrated.

The inferior wall may be dismissed from further consideration, and we come to the description of *the anterior wall* of the sinus. Directed downward and backward at an obtuse angle to the cribriform plate, this face may be said to be divided into two areas:

First. The area abutting the lateral masses of the ethmoid and forming with them some of the posterior ethmoid cell walls, (Fig. II. 8.) and

Second. The free area making up the posterior curve of the nasal dome, (Fig. II. 9.)

The latter area presents a point of selection for entrance into the sinus, its plane being at an angle of 45 degrees to the nasal floor. In the median line it gives attachment above to the perpendicular plate of the ethmoid and below to the superior part of the vomer. At the lower border the face is curved backward and loses itself in the inferior face. The free surface is in relation above to the ethmoidal notch at its junction with the lesser wings of the sphenoid, below which is the spheno-ethmoidal recess, and the superior and inferior ethmoidal fissures in their order from above downwards. The width of the anterior wall is on an average from 28 to 30 millimeters. Vertically the measurement varies with the development of the sinus, but roughly speaking, is apt to be about 18 to 20 millimeters. The sphenoidal recess so called, is the space into which the ostia of the sinus open on either side. One or two of the posterior ethmoid cells may empty into this recess, in which case it would become a fact of pathological importance in considering empyemas of the sphenoid, and a possible cause of infection of the posterior cells. The recess separates the attachment of the turbinates from the an-

terior wall of the sinus, extending laterally between the posterior cells and the anterior wall. One of the posterior cells generally forms its roof on the external aspect.

The ostia are situated usually about 4 millimeters below the superior border of the anterior face. The orifices themselves are oval in shape, two to three millimeters in their vertical, and one to two millimeters in their transverse diameters (Fig. II. 11.) They are easily found by a probe introduced into the nose in the following manner:

If a probe bent similar in shape to a Eustachian catheter, but less curved, is passed between the cocainized middle turbinate and the septum, its convexity approximating the cribriform plate, the end after passing 7 to 8 centimeters from the entrance to the vestibule, will abut against the anterior wall of the sinus. By gently prodding and carrying the end up and down or rotating slightly, we suddenly find the resistance overcome, and the probe will further advance from 1 to 2 centimeters. Having fixed in one's mind the direction of the probe, and the distance of the wall having been measured on the shaft, a Eustachian catheter may be bent in such a way that it will follow the route taken by the probe, and we may conveniently evacuate the sinus by suction and judge of its contents. If the catheterization of the sinus gives evidences that determine us to make a resection of the anterior wall, it is always preferable to remove the middle turbinate before attempting to enlarge the orifice of the sinus. In making a resection of the anterior wall, it is well to remember that the posterior cells are in apposition to the outer surface of the anterior face, and that frequently a cell makes an excursion into the sinus, or on the contrary the sinus may intrude the region of the posterior cells. If we break down the portion of the anterior wall which collaborates in making the wall of the posterior cell, we may cause an infection of this group of cells.

Sieur and Jacob have found the excursion of the sinus to take place into the lesser wings and anterior clinoidal processes in one case in every twelve examined, and point out that we can readily understand how easily accidents may injure the foramina whose walls are rendered fragile by such an extension of the sphenoidal sinus. An amaurosis might occur in consequence of such an injury, by an interference with the vitality and nutrition of the optic nerve. Here also is an opportunity of infection in case of empyema, for the walls of the sinus would be only separated from the nerve by the merest shell of bone. An empyema of the sinus may in like manner become a starting point for a carious process of the lesser wings of the sphenoid bone.

The prolongations of the sinus which may extend into the antero external inferior angles are of the greatest surgical importance and in the choice of operations upon the sphenoid the possibility of such abnormalities must be taken into serious consideration. The superior internal posterior angle of the maxillary antrum is completed in its orbital aspect by the orbital apophysis of the palatine bone. This process continued backward, forms the internal wall of the spheno-maxillary fissure posteriorly. It forms the external wall of that posterior ethmoid cell (Sieur's cell) which separates the sphenoid sinus from the antrum.

This cell is that connecting link between the sphenoidal and maxillary sinuses at the expense of which the excursions from one sinus toward or into the other may occur. This happens in one out of four subjects*. It is in juxtaposition with the sphenoidal sinus at the outer inferior angle of the anterior face and with the maxillary sinus at its postero-superior internal angle.

Separating the two large sinuses it may open into the one or the other. It is bounded above by the posterior cells to which group it properly appertains. Externally its wall forms the deepest part of the spheno maxillary fissure, curving inward its base overhangs the spheno palatine foramen and ganglion. The superior maxillary nerve at its exit from the foramen rotundum to enter the infra orbital canal, is also in contact with the wall of this important cellule. Its inside wall has to do with the posterior part of the superior meatus.

In the palatine excursions of the sphenoid sinus we thus find a cul-de-sac directed obliquely downward and forward, a veritable pus trap in empyemas, which might be thus the starting point of a maxillary sinus infection.*

Were it not for the dangerous proximity to the optic and superior maxillary nerves and the spheno palatine vessels and ganglion, this would be an ideal route by which to enter the sphenoid sinus by way of the canine fossa through the supero-posterior internal angle of the antrum. While by this method we might obliterate a palatine cul-de-sac; by penetrating the palatine apophysis we would take such unwarranted risks of wounding the spheno-palatine nerves and vessels that we must not consider the surgical entrance of the sphenoidal sinus, through this angle. I speak of the objections to this route because Dr. Cryer of Philadelphia recommended this operation before the New York Academy of Medicine at a meeting in February of last year. Furet, Jansen, Luc, Mosher and others

* S. and J., *loc. cit.*

have developed the surgery of the entrance to the sphenoid through the canine fossa and middle meatus in such a manner that the above mentioned dangers are happily avoided.

"The excursions of the cavity of the sphenoid into the greater wings are less frequently encountered than the palatine prolongations. They may be unilateral, bilateral or unequal. They extend vertically or obliquely downward and outward at the expense of the greater wings, or they may invade the pterygoid plates. These excursions of the sinus may incorporate the round and oval foramina and render their bony rings extremely thin. In fact the superior and inferior maxillary nerves may be only separated from the sinus by a thin papyraceous wall of delicate bone, the venous plexus surrounding the nerves being anastomosed with the venous supply of the mucous membrane of the sinus. A similar condition exists as regards the optic canal when the sinus invades the anterior clinoid processes and the lesser wings, a fact we have mentioned above. These anomalies explain the infection of the trigeminus and particularly the superior maxillary nerve, in pathological affections of the sphenoidal sinus. In one case in fifteen the sinus obtrudes the space between the round and oval foramina and invades the roof of the pterygo-maxillary fossa."* The importance of conservative surgery is seen when one estimates the accidents which may arise from the even gentle curettement of these prolongations.

Even greater danger than the injury to important vessels and nerves comes from the possibility of infection which is so generously invited by the anatomical relationships of this most mysterious sinus.

Jansen of Berlin has developed the surgery of the sphenoidal sinus operation through the maxillary antrum in an ingenious manner, but there always remains a question as to whether the dryness of the nasal cavity which is an almost invariable result of this radical operation, is not a very grave objection to the procedure.

In reviewing the anatomy, we must remember that the cavity of the sphenoidal sinus may intrude the lesser wings at the base of the anterior clinoidal processes, at the anterior inferior angles, or, in the region of the junction of the great wings and the pterygoid apophyses. More rarely we find prolongation of the cavity into the rostrum, into the posterior clinoidal processes, as well as into the basilar process of the occipital bone.

The sphenoidal sinus, should be properly spoken of in the plural, as there are two of unequal size separated by a bony septum of such integrity that it is rarely broken down by disease. The sinus is lined by a mucous membrane of three layers. The first consists of ciliary

* *Loc. cit.*

epithelium, under which lies the basement membrane with its numerous vessels and muciparous glands, which are particularly abundant around the orifices. Then comes the periosteal layer with scarcely any vessels but perforated by the numerous veins which penetrate the walls in every direction and communicate by their canaliculi with the cavernous sinus, the vessels of the optic canal and the sphenoidal fissure. These canaliculi also penetrate the sella turcica, as well as the walls which collaborate in forming the posterior ethmoid cells. We observe in what close relationship is the venous circulation with the adjacent sinuses. The arterial supply is from three sources: The spheno-palatine artery sends branches to the mucosa through the orifices of the sinus, while the pterygo-palatine and the vidian contribute branches which penetrate the anterior walls. The largest veins exit by the orifices, while the smaller trunks higher up perforate the walls and empty into the ophthalmic veins and the coronary and cavernous sinuses, as has already been described. The lymphatics connect with the ganglia of the neck and also with the pharyngeal lymphatics. From the fact that the spheno-palatine arteries and the venous trunks send branches through the orifices of the sinus we are to expect more or less hemorrhage on entering the anterior wall in this direction.

Enough has been said of the anatomy of the sinus to give an idea of the very intimate relationship which exists between it and the important nerves and vessels which lie adjacent to it. We must constantly bear in mind the possibility of the serious consequences which may ensue from lack of appreciation of these relationships. In no other sinus of the cranium is a perfect knowledge of the anatomy so essential from an operative standpoint as well as from that of the diagnostician.

In 1886, Captain H., an officer in the U. S. army, who had been retired on account of chronic catarrh with intolerable and constant pain in the head referred to the occiput and vertex, presented himself at my office. The suffering of the patient was so acute that I made every effort to relieve him. It was evident to me that the profuse discharge from the pharynx did not arise from the nose and it appeared to always originate from either side of the septum at the junction of the vomer and sphenoid.

At first it occurred to me that it came from the posterior ethmoid cells and I spent much time in attempting to find pus in the nasal cavity but without success. I finally determined that it must come from the sphenoid sinus.

After several months of experimenting, I finally persuaded the patient to undergo an operation, or rather he persuaded me to oper-

ate, for he was ready to have anything done to relieve his pain. I selected the anterior wall as the seat of operation and as a preliminary removed the left middle turbinate, being rather skeptical in my own mind as to the outcome of even this slight procedure. With the cessation of his hemorrhage and my anxiety, I was surprised to find that I could see the field of operation very well, and after washing the nose, a discharge was visible, oozing from an opening of the sphenoidal wall. I probed the orifice and found a large sinus full of brownish pus; I then took a long shafted trephine, which I had previously had constructed for use in nasal work, and enlarged the opening, a thing I found easy of accomplishment, for the anterior wall was very necrotic. The other orifice I syringed by means of a catheter I had made especially for this purpose and exhibited at the section meeting of the New York Academy of Medicine in March, 1889, when I reported the case. I afterwards described this operation in the section meeting of November 28, 1894.*

So great was the relief to the patient that I did not venture to operate on the other side but merely made a large opening in the left anterior wall.

The patient was delighted with the result and was perfectly content to syringe out his sinus daily, never expecting any more radical relief than the stoppage of pain. The discharge was diminished very much and the patient lived several years finally dying of pneumonia. Dr. Geo. E. Brewer now assistant surgeon of Roosevelt Hospital assisted in the treatment of this case and saw him at various times after he had passed from my observation. I may be excused for citing this experience as I believe it to be the first operation done on the sphenoid sinus through the natural orifice. At that time the text-books did not mention empyema of the accessory sinuses, and ethmoiditis had no place in rhinology. It was the experience I had with this case that led me later to investigate ethmoiditis and the accessory sinus empyemas from an intelligent standpoint. I have repeatedly done this operation since that time, removing larger portions of the anterior wall and curetting the cavity. Packing the sinus has never been practiced with my cases and even simple syringing has sometimes given rise to great pain, nausea, and all the symptoms of a meningitis with the exception of the temperature.

This occurred in a case operated on last month in which a girl of eighteen, after a simple exploratory probing and syringing of the sinus, was confined to her bed for two days with most violent pain and vomiting, but with, fortunately, only a rise of one degree in her

* *Am. Med. and Surg. Bull.*, vol. vii., pp. 1516.

temperature. The pain was referred to the occiput and vertex. In operating the utmost gentleness should be used in entering the sinus, and the curettement of the walls should be accomplished with a delicate touch. The barrel dental drill with a probe point suggested by Dr. Balance I have found very useful in enlarging the natural orifices of the sinus and I am also indebted to this instrument for a comparatively safe method in entering the naso-frontal duct. I have had good results from dusting the cleansed cavity with pyoctannin and boric acid (1-9) after drying the sinus. In the majority of cases I have seen, it has been difficult to ascertain the exact condition of the sphenoid sinus when operated on in this way. My later experience has shown how rarely does a case occur in which we are not obliged to more fully destroy the posterior ethmoid cells.

In closing this description of the surgical relations of the sphenoidal sinus, it is well to disclaim any great amount of originality of theme. The pathological deductions and much material have been taken from that greatest of rhinological works "Les Fosses Nasales," by Sieur and Jacob who, with Lathrup in our own country and Logan Turner in Scotland, have given to the profession the benefit of most painstaking and laborious research.

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Tubercular Sinusphlebitis—F. GROSSMAN—*Archiv f. Ohrenheilkunde,* Feb., 1904.

The author reports six cases. He concludes that the disease is not carried along the sinus by the growth of the blood-clot, but that the latter is of secondary appearance. The disease spreads by the growth of the tubercular granulation tissue along the intima of the sinus, the blood-clot spreading only as far as the wall of the vessel is diseased.

The tuberculosis is generally of the miliary variety, though a fibrous form has been described. Tubercle bacilli are found in the tissue.

In about one half of the cases the disease is followed by tubercular meningitis. Cases of mixed infection ((staphylococci and B. pyocyaneus) have been described, and an ordinary acute septic phlebitis may run its course in a tubercular subject without itself being of a tubercular nature.

YANKAUER.

FOURTEEN CASES OF CHRONIC MULTIPLE SINUSITIS (MAXILLARY ANTRUM, ETHMOID CELLS AND SPHENOID SINUS) OPERATED UPON BY WAY OF THE MAXILLARY ROUTE.*

BY T. PASSMORE BERENS.

The writer confesses to such a confusion in his own mind as to whom belongs the credit for the operation performed on the following cases that he thinks it better to try to name the route taken rather than to endeavor to give the credit to the proper author or authors who may first have described it. Jansen, Boeninghaus, Luc and others probably all about the same time concluded that the maxillary route was a good one in certain cases, and the differences in their operations, if any exist, probably are in minor details only. The writer became familiar with the advantages of the operation through the courtesy of Jansen in Berlin about two years ago, and the operation described is with slight changes similar to the operations he saw performed by Jansen at that time.

An apology is due perhaps for describing the operation again so shortly after its publication in THE LARYNGOSCOPE (March, 1904); but the description of it now is essential for the understanding of these cases, and moreover, it is considered to be so useful that the repetition may be pardoned.

The operation is performed under æther anæsthesia and with the aid of an electric head light, as follows: The jaws are held apart by a mouth-gag inserted on the well side. The choana of the diseased side is tamponed by a post-nasal tampon of cotton. To prevent blood reaching the pharynx from the mouth, a gauze sponge is held by dressing forceps between the jaws and the cheek of the affected side at the juncture of the posterior ends of the upper and lower alveoli. The cheek is retracted by a blunt retractor held by an assistant. The tongue is held forward by a silk ligature passed through it. This prevents delays by the tongue falling backward. An incision extending from the posterior end of the alveolus to the anterior border of the canine fossa is made through the mucous membrane periosteum, just below and parallel with the attachment of the cheek. A periosteal elevator is then used to free the anterior and

* Read at the Tenth Annual Meeting of the American Laryngological, Rhinological and Otological Society, held at Chicago, May 30, 31 and June 1, 1904.

lateral convex surface of the antral wall from its periosteum and soft parts. The bleeding is controlled by pressure with gauze. The antrum is opened by a chisel sufficiently to allow of the use of a rongeur, which is then used to remove the outer wall of the antrum, anteriorly to its junction with the internal wall, inferiorly to the floor, superiorly almost up to the intra-orbital canal and posteriorly along the external wall to just behind the anterior border of the masseter muscle. This part of the operation is nearly bloodless unless the lining membrane of the antrum is wounded. The membrane is then incised and the cavity inspected. After completely removing the lining of the antrum with a large, sharp curette, the bony internal or nasal wall is removed, anteriorly to the junction with the external wall, posteriorly to its junction with the posterior wall, and inferiorly to the floor of the antrum with the same instrument, care being taken to preserve all of the membrane on the nasal side. The superior part of this wall, which is formed by the ethmoid cells, is removed with the sharp spoon, as are all of the ethmoid cells and also the middle turbinate. A superior turbinate process is sometimes present and is removed. The opening to the sphenoid sinus is now plainly visible. As much as possible of the anterior wall of the sphenoid is removed laterally, and always to its floor with a sharp curette, as is the diseased tissue lining the cavity. During these various procedures the cavity is frequently dried with gauze soaked in 1-1000 adrenalin solution, which usually controls the hemorrhage, at times quite troublesome. The upper part of the membranous wall usually is destroyed, but its lower two-thirds are preserved intact. The inferior turbinate bone is freed from its membrane piecemeal, both with the rongeur and with the sharp spoon, leaving the mucous membrane in a long strip attached anteriorly and posteriorly. This procedure is facilitated by the insertion of the small finger into the naris, which affords counter pressure. After the wound is thoroughly cleansed, the remnants of the nasal mucous membrane, consisting of tissue from the inferior turbinate and from the lower two-thirds of the nasal wall, are utilized as follows: That remaining from the wall is freed from its anterior attachment and is drawn into the cavity of the antrum, covering in large part the anterior wall and part of the floor. It is anchored by a stitch to the superior lip of the wound in the mouth, near its anterior end. The mucous membrane of the inferior turbinate is divided at the posterior end of its anterior third, and the posterior flap thus formed is placed along the floor of the antrum and anchored by a stitch to the inferior lip of the wound; while the anterior flap of turbinate mucous membrane is anchored around the "anterior angle." The result is that the lower

and anterior part of the antrum is fairly well lined with a functionating mucous membrane. The whole wound, from the interior of the sphenoid sinus to between the lips of the oral wound, is packed with iodoform gauze. The oral wound is not stitched.

Stitching of the oral wound, as advised by Jansen, was not practiced in any of the cases, owing largely to the uncertainty in the mind of the writer of the wisdom of the procedure; and it was certainly a great comfort to be able to see the process of repair and to know beyond a doubt just what was taking place in the operated area.

In the first few cases operated upon the packing was carried much longer than in the later cases, which were packed at the time of operation, the packing being removed in three to four days and not reinserted. The highest temperature recorded in any case was 103½°, and this was attributable to other causes; in all of the other cases 100½° was the maximum.

Opiates were administered in nearly all of the cases for the pain immediately following the operation. After the first 24 hours iced cloths were found sufficiently efficacious to control the pain.

Each patient, excepting *Cases 6* and *9*, was in the hospital one week only, and in the cases of the males they resumed their customary vocations in two weeks.

Case I. Man, age 35, presented for examination in November, 1902, on account of "catarrh" and severe paroxysmal neuralgic pains in the occiput, vertex and face, which had been diagnosed *"Tic Douloureux."* His history dated back for 16 years when he had polypi removed from his left nostril. Since that time he had had treatment of his nose, including removal of the left middle turbinate, washing out of the antrum through the nose, and opening of the antrum through the canine fossa. Examination of the nose revealed pus exuding from the antrum, from the anterior and posterior ethmoid region, as well as from a small fistula in the canine fossa. Operation showed the antrum to be nearly filled with myxomatous tissue, the ethmoid cells extensively diseased and the sphenoid sinus, which was entered from the posterior ethmoid cell, contained much pus and granulation tissue. The inferior turbinate freed from the bone was used as a flap to line the floor of the antrum. Packing was carried five weeks and the patient was under treatment at intervals for six months, owing to a constant suppuration from some overlooked ethmoid cells which were later removed with a curette under cocaine anæsthesia. There has been no neuralgia since the operation. Recent examination reveals no pus.

Case II. Man, age 38 years, presented for examination December, 1902. He had had a profuse, foul-smelling nasal discharge from the left side of the nose for 20 years, with neuralgic pains in the face, vertex and occiput. He had considerable intra-nasal treatment, surgical and otherwise, which had given him relief at various times and for varying periods, only to have a return of his discharge and neuralgia when the treatments were discontinued. The dentists had extracted his bicuspids and molars from the affected side. It was not his fault that he had derived no benefit for he was most anxious to be relieved and readily consented to the radical operation. This revealed the antrum to be literally packed with myxomatous tissue, as were the ethmoid cells, the superior and middle meati of the nose and the sphenoid sinus, which latter apparently communicated with the posterior ethmoid cell through which it was entered. The inferior turbinate tissue and the mucous membrane covering the nasal wall of the antrum were myxomatous and were removed, leaving no tissue for flaps. The patient carried the packing for five weeks and was treated five months in all because of a return of pus in the middle ethmoid region, accompanied by a tendency to polyp formation. This condition was relieved by removing with a curette under cocaine anæsthesia a small mass of cellular bony tissue—evidently small ethmoid cells overlooked at the time of operation. Recent examination shows the patient cured. He has had no treatment for several months.

Case III. Woman, age 65, presented for examination December, 1902. She had had her teeth extracted when 40 years old on account of right-sided trifacial neuralgia, which was not relieved by the operation. Since that time she had had her middle turbinate removed, the ethmoid cells partly curetted and her antrum opened and packed for several months through the canine fossa. The oral wound healed, but her neuralgia and pus persisted. For a year before she presented for examination she had had no treatment other than a nasal douching at home. Examination revealed pus oozing from between numerous polypi which filled the middle meatus. The right antrum failed to trans-illuminate. A probe entered the antrum just behind and above the anterior end of the inferior turbinate and gave vent to a free discharge of fœtid pus. Operation disclosed a perforation about the size of a dime through the canine fossa, filled in with fibrous tissue. Deeply imbedded in the floor of the antrum was a tooth root, probably a molar fang. The osteum was much enlarged by disease and the antrum and ethmoid cells were filled with myxomatous tissue, necrosed bone and pus, while the

sphenoid sinus was filled with pus and granulation tissue. Its anterior wall was necrosed and very soft. No flaps were obtained. The patient carried the packing for six weeks. She was under treatment, which consisted of home douchings and office treatments with caustics for six weeks longer. Recent examination failed to reveal pus or crusts. There has been no return of neuralgia.

Case IV. Woman, age 40 years, presented by Dr. R. T. Howe for examination January 8, 1903. The history dates back 18 years when she had all of the teeth extracted from the left upper jaw on account of neuralgia, which was not relieved by their removal. The patient had been under treatment 12 years ago by Dr. Howe for pain in the inner canthus of the left eye and pus from the nose. The doctor had from time to time removed polypi and part of the middle turbinate from the left nostril, without relieving the discharge, although the pain in the eye was lessened. She had considerable headache localized about the eye and in the temporal region, no pain in the face. Three months before she had had an alveolar abscess opened on the upper left jaw with evacuation of pus. Examination revealed pus on the floor of the nose and exuding from the ethmoid region and the region of the *Hiatus Semilunaris.* Transillumination was complete, excepting of the left antrum and about the inner canthus of the left eye, where it showed dark. A probe discovered necrosed bone at the site of the alveolar abscess, but the probe, which was a very small one, did not enter the antrum. This case was operated on January 17, 1903. A prong of the root of the first molar tooth was found imbedded in a mass of granulation tissue on the floor of the antrum at the inner end of the fistula. The antrum and the ethmoid cells were filled with myxomatous tissue. The sphenoid sinus was thoroughly explored, but found healthy. Good flaps for lining the antrum were secured from the inferior turbinate and from the lateral wall. The packing was carried for four weeks. The patient was under occasional treatment until May. She was seen recently and found free from pus and pain. There remains a small fistula at the site of the oral wound which causes no discomfort. A recent severe attack of coryza with muco-purulent discharge from both nostrils caused much less trouble on the operated side and cleared up more rapidly than on the unaffected side.

Case V. Man, age 36 years. This patient was under treatment in the Manhattan Eye and Ear Hospital for a neuro-paralytic Keratitis with paralysis of the fifth and sixth nerves of undetermined origin; and was referred to the writer February 15, 1903, for what

proved to be a catarrhal deafness in the left ear. He had had a discharge of pus from the left nostril for three years, but no pain, which was accounted for by the anæsthesia present. A diagnosis of empyema of the ethmoid, antrum and sphenoid was made. Operation proved the diagnosis correct. All of the sinuses and cells were filled with myxomatous and granulation tissue. Packing was carried in this case for four weeks, and the cavity was douched four weeks longer when all suppuration had ceased excepting from a small area in the ethmoid region. The result on the anæsthesia was *nil.* The patient died of acute tuberculosis several months later.

Cases VI and VII. (This patient is reported as two cases because of the double operation). Man, age 24 years, presented for examination February 24, 1903, with a history of nasal suppuration and faulty nasal respiration dating from scarlet fever fifteen years before. He had severe pain over the right orbit and at the vertex of the skull, with occasional pains in the occiput and a constant sense of fullness in both antra. Both ears were discharging. Examination of the nose revealed foul-smelling, creamy pus lying on the floor of both nostrils, with pus exuding from the region of the *Hiatus Semilunaris* on both sides. Pus was detected by posterior rhinoscopy oozing from high up behind the middle turbinate. Pus was exuding also from the region of the right infundibulum. A large perforation was present in each membrana tympani with pus, and also granulation in the right middle ear. Trans-illumination failed in both antra and the right frontal sinus, while the left frontal sinus did trans-illuminate, showing an unusually large cavity. A diagnosis of pansinusitis, excepting the left frontal, was made, and the patient was operated on for his frontal right antrum, ethmoid and sphenoid at one sitting, requiring about 1½ hours. All of the cavities were diseased and contained much granulation and myxomatous tissue. Good flaps were secured for lining the antrum. Two weeks later the left antrum, ethmoid and sphenoid were operated upon and found to be similarly diseased. Fairly good flaps were secured. At the time of the second operation the right ear was curetted and necrosed ossicles removed. This patient had each antral wound packed for three weeks and they were treated by douchings for about two months longer—in all about three months. The frontal sinus was packed four months. It was unusually large. His recovery was uninterrupted and he is now perfectly well.

Case VIII. Woman, age 36 years, presented for examination March 5, 1903. Five years before she had had the second bicuspid tooth in the right upper jaw removed because of disease in its root

accompanied with pain in the right antrum. Since that time she had had a yellow, foul-smelling discharge from the right nostril. This discharge was aggravated by *la grippe* one year ago. She had frequent attacks of headache on the right side radiating from the inner canthus of the right eye to the vertex and occiput. Of late she had had but little pain in the antrum. Examination revealed two molar teeth much diseased in the right upper jaw. The nose contained much foul-smelling, greenish pus, which exuded from beneath and from above the middle turbinate. The latter was enlarged and crowding its natural space. This mass, together with much myxomatous tissue, was removed under cocaine anæsthesia, and for several days the patient experienced much relief from pain. The suppuration continued, and the pain returned, however, and on April 2, the radical operation was performed. The antrum was found filled with myxomatous masses as were the ethmoid cells. In curetting the posterior ethmoid cell, the sphenoid sinus was entered, found diseased, its anterior wall removed and the contents, myxomatous tissue and pus, removed with a curette. The inferior turbinate and a considerable portion of the nasal membrane of the naso-antral wall were secured as flaps. The wound was packed for a month. Recovery was complete in two months. The wound in the mouth closed four months after operation.

Case IX. Woman, age 72 years. This case was reported in full in THE LARYNGOSCOPE (March, 1904). She gave a history of neuralgia and removal of teeth for its relief 30 years before. She had carried an antrum drainage tube through the alveolus for several years. Her neuralgia was most marked in the face, but extended into the vertical and occipital regions. The diagnosis of antrum and ethmoid disease was proved correct by operation. The sphenoid disease was not diagnosed until at the operation. Good flaps were secured. Packing was carried 16 days. There was complete relief from pain until three months later, when a return of pain was accompanied by suppuration in the sphenoid. As this subsided, her pain left and did not return until a few days ago, when suppuration was again found in the sphenoid sinus.*

Case X. Woman, 53 years old, presented for examination November 12, 1903 . She gave a history of supposed trouble with teeth for which they had all been extracted from the right upper jaw, and of having had the right antrum opened through the alveolus six years before. She complained of no pain, but was troubled by the discharge of foul-smelling pus from the fistula in the alveolus

* Patient examined October 29th. No treatment since June 15; found perfectly well.

and from the nose. Examination revealed pus exuding from the osteum and posteriorly from beneath the middle turbinate. Posteriorly pus was exuding from the region of the sphenoid, and a cotton-armed probe brought forth pus and blood from the sphenoid. She was operated upon November 21, 1903. Much pus, granulation tissue and detritus were found in the antrum, ethmoid and sphenoid. Good flaps were secured. Much bleeding, arterial in character, took place near the sphenoid cavity on the lateral wall. This was easily controlled by artery forceps. The packing was carried five days only. In three weeks the patient left the city, and douched the cavity herself for two months. Recent examination proves her cured.

Case XI. Man, 45 years old, presented for examination November, 1903. History of discharge from the nose for nine years, dating from *la grippe*. He had had the antrum washed out through the nose and had had considerable intra-nasal surgery performed by another surgeon. The patient complained of no pain. Examination revealed much myxomatous tissue in the region of the middle turbinate, which was absent. Pus was exuding from between the polypoid masses. A probe readily entered the antrum and sphenoid. In each instance it was followed by pus. Operation revealed a myxomatous disease of the antrum, ethmoid and sphenoid. Good flaps were obtained. The patient carried the packing ten days and made a complete recovery, including closure by cicatricial contraction of the mouth wound in three months.

Case XII. Woman, age 63 years. Had the teeth extracted many years before for neuralgia, which at times was severe, and had been called "*Tic Douloureux*" by her physicians. The writer operated on her right frontal sinus and antrum in 1899 after a preliminary course of operative treatment in the ethmoid region. The frontal sinus healed by granulation after several months of packing. The antrum was freely opened by way of the canine fossa, thoroughly curetted, and apparently healed; but the suppuration continued from the nose and the pain in the occipital and vertical region and in the face persisted. The pain in this case was particularly severe at the vertex and in the occiput. In June, 1903, she submitted to the radical operation. There was much hemorrhage, especially from the external lateral wall of the antrum, from which was curetted a large mass of what Dr. Jonathan Wright subsequently reported to be a probably malignant adenoma. There was also much bleeding, arterial in character, in the position of the spheno-palatine foramen. The bleeding was controlled by artery forceps. The ethmoids and the sphenoid were found badly diseased, containing tissue similar in character to

that removed from the antrum, but this tissue was lost. No flaps were saved, and the case was packed for two weeks, when the patient was given a douche which she used all summer. She had complete relief from the pain, but a slight discharge persisted. Recently there has been some pain over the malar bone, and the growth is again visible and growing rapidly. The pathological report from Dr. Jonathan Wright is confirmatory of his previous diagnosis.

Case XIII. Female, age 22 years, presented for examination April 2, 1904, giving a history of a decayed molar tooth in the right upper jaw, with occasional attacks of face-ache and pain in the eye, extending backward into the occiput. These pains were relieved by a discharge of pus from the right nostril. The pains and discharge had been present for many years and the patient claims to have had the discharge since twelve years of age. Examination revealed both molar teeth badly decayed to the roots. The second bicuspid tooth was absent. Pus was oozing from the region of the osteum, the posterior ethmoid and sphenoid regions. The sphenoid opening was not found, owing to the presence of an unusually large middle turbinate. Operation revealed a large fang of a tooth (second bicuspid) lying almost free in the antral floor. The molars had been removed by a dentist before the operation. The posterior half of the antrum was divided by bony partitions into a pneumatic cellular structure. These cells as well as the main cavity of the antrum were filled with pus, myxomatous tissue and granulations, as also were the ethmoid cells and sphenoid sinus. The latter was entered through a large posterior ethmoid cell. Good flaps were obtained in this case. The patient carried the packing for four days only, was discharged from the hospital in one week, and in less than two weeks from the time of operation was attending to her duties as general house-maid. One month after operation she had a severe coryza with as much watery secretion from the operated side as from the unaffected side. The inferior turbinate was in a state of erection. No harm resulted from the coryza, and she is now free from pus and pain.

Case XIV. Female, age 40 years, presented for examination April 30, 1904, with a history dating from about one year before when she had had *grippe*, which was accompanied by pain in the antrum, vertex and occiput, and much purulent discharge from the nose. This latter cleared up under treatment, but the discharge from the left side persisted in spite of considerable intra-nasal treatment by another physician. Examination of the nose revealed pus exuding from the anterior ethmoid cells, from the region of the osteum and from the region of the sphenoid sinus. A cotton-armed probe

brought pus from the sphenoid. On probing the anterior ethmoid region, the probe entered three distinct spaces through one opening; the first direction taken was high up lateraly and anteriorly; the second, high up posteriorly and laterally; the third, high up and anteriorly. The first two cavities entered discharged pus on the withdrawal of the probe, and denuded bone was detected. It was considered that the first two cavities entered were the *bulla ethmoidalis* and an unusually large anterior ethmoid cell occupying a higher position than usual. The last cavity entered did not discharge pus, and no bare bone was found. It was supposed that this cavity was the frontal sinus. The writer was considerably perplexed by this condition, and especially so since the patient had been told by two good rhinologists that she had frontal sinusitis. Trans-illumination did not help the diagnosis, for both frontals failed to trans-illuminate, as did the left antrum. After carefully confirming the result of the first examination, it was concluded that the frontal was not affected, and on April 28, the antrum sphenoid and ethmoid were thoroughly curretted. They were all found to contain pus and myxomatous tissue. While operating in the ethmoid region, the anterior ethmoid cells were explored with great care well up into the region of the floor of the frontal sinus. Considerable pus was found in the *bulla* and a large cell that was found anterior to it. No flaps were obtained. The patient carried the packing four days and was not repacked. There was no discharge found on the dressings. Pus appeared for a few days in the douchings, but none has been found coming from the frontal region, and for two weeks there has been no pus found. The oral wound has nearly healed, and judging from the experience gained from previous cases, this patient will be entirely well within the month.*

To summarize: All of the patients but one had disease of the sphenoid sinus; in twelve of these occipital and vertical pains were present; in eight—all with sphenoid disease—the pains extended also into the face and were neuralgic in character; while in four cases the pains closely simulated *"Tic Douloureux."* These cases were all cured except two, viz: *Case 12,* which was malignant, and *Case 9,* in which suppuration returned several times in the sphenoid, each return being marked by an attack of *"tic."* It seems to the writer that the presence of pain in the vertex and occiput or in tregiminal neuralgia when accompanied by pus in the posterior nares, is symptomatic, almost diagnostic of sphenoid disease.

In twelve of the patients there was pain in the region of the eye, especially in the region of the inner canthus. This pain was ex-

* Patient has been well since the middle of June.

plained at the time of operation by the finding of disease in the most anterior ethmoid cells.

In all of the cases excepting *Case 5* there was a total absence of frontal sinus disease; and since they all were chronic cases, most of them of many years duration, it is interesting to ask: What factor was present to preserve the frontal sinus from the primary infection, to cure it if it was infected, or to protect it if from subsequent invasion by the disease already established in the ethmoid region? Were the teeth the prime factors of the infection of the antrum, with a subsequent extension of the suppurative process upward and backward into the ethmoid cells and sphenoid sinus; and if so, why, again, did the frontal sinus escape? In eight of these cases the teeth were found diseased at the time of operation, or there was a clear history of diseased teeth, at least of dentalgia. That diseased teeth cause many cases of antrum disease is not questioned, but on the other hand the writer believes that many a tooth has been sacrificed when proper treatment of the antrum would have saved it. A tooth having roots protruding into a suppurating cavity—the roots protected by only a thin mucous-membrane periosteal covering—could readily become diseased by contiguity of tissue; and the writer believes that in at least some of his cases this actually had taken place, at least to the extent of producing dentalgia.

In all of the cases excepting *Case 12* and *Case 9* there was a complete and permanent relief from pain following the operation.

Of the nine cases operated upon more than a year ago four have had a return of pus. Two of these returns were in the ethmoid region and were cured by subsequent curettement; one was malignant; and one was in the sphenoid. The continued suppuration in the latter case was probably due to a prolongation of the sinus into the wing of the sphenoid bone, or some other similar condition. The return of pus in the ethmoid region was the result of fear born of inexperience of perforating through the internal plate of the ethmoids. Experience having given a better technique, the cases operated upon later had practically a complete exenteration of the ethmoid cells and have not since suppurated.

There has been a troublesome crust formation in four cases; but there was an atrophic process present throughout the whole of the nasal cavities before operation in these patients.

The tear-duct was cut off in at least half the cases, but this has caused no symptoms, the duct simply emptying higher up.

Arterial hemorrhage deep in the wound was easily controlled by artery forceps in three cases. The possibility of hemorrhage in this locality certainly demands the most open kind of a wound that it is possible to secure in any operative procedure that may have to be undertaken. In any of these three cases the hemorrhage would have been practically beyond control had the operation been performed by the *intra-nasal route.*

In conclusion, the operation as described is advised only after a careful study of each case, and where the hope of a cure by milder measures can not be held out to the patient.

35 Park Avenue.

ORBITAL INFECTION FROM THE ETHMOID CELLS WITH SPONTANEOUS OPENING AT INNER ANGLE OF ORBIT.*

BY CARL E. MUNGER, M.D., WATERBURY, CONN.
Assistant Surgeon Manhattan Eye and Ear Hospital, New York; Laryngologist and Aural Surgeon, Waterbury Hospital.

That cases of suppurating ethmoiditis should at least occasionally result in an extension of the disease from the nasal to the orbital cavity is not to be wondered at when is recalled the thinness of the lamina papyracea and the position of the anterior and posterior ethmoidal foramina, and that these cases should have been referred to and have been treated by the ophthalmologist formerly rather than by the rhinologist is also something that should be remarked.

In studying up the literature of orbital abscesses having an ethmoid origin, it is apparent that the number recently reported is much less since the rhinologist has been developed and the knowledge of intra-nasal diseases has increased and intra-nasal surgery has become more nearly perfected. This is undoubtedly due to the earlier diagnosis made possible by our more extended information as to ethmoid diseases and the greater promptness with which the ethmoid region is attacked surgically.

Cases of orbital infection from the ethmoid cells do occur as evidenced by the reports of such cases, and as Bosworth has stated, "pus should escape through the nose but in many cases it escapes through the os planum into the orbital cavity." Most examples of this occurrence are chronic in character coming on only after a long duration of ethmoid trouble but with noticeable exceptions, *i. e.*, the case reported by W. N. Hubbard in which the orbital abscess came on shortly after a case of tonsillitis, probably of influenzic origin, in a patient with no previous history of ethmoid involvement; and the case reported by Milligan where an ethmoiditis followed a severe attack of a cold in the head and this in a short time followed by the appearance of an orbital swelling in the region of the inner canthus. The orbital symptoms vary in intensity from a slight uneasiness in this region to severe pain, profound depression of spirits, ptosis, exophthalmos, marked tenderness, diplopia, proptosis and even partial loss of vision due to affection of the optic nerve.

The case which I wish to call your attention to is not unlike most of the cases which have been reported, but presents some features

* Read at the Tenth Annual Meeting of the American Laryngological, Rhinological and Otological Society, held at Chicago, May 30, 31 and June 1, 1904.

of interest. W. L., male, age 50, came under my observation in November, 1903, with the history of rather marked and persistent pain in the right supra-orbital region and a moderate amount of aprosexia. He had a peculiar sweetish and very insistent odor emanating from the nose. Examination of the nose showed a moderate degree of atrophy of the inferior turbinate and the middle turbinated body looked atrophic as to its mucous membrane although as a whole it was rather prominent. There was a sharp exostosis pressing on the lower part of the middle turbinate. There was no tenderness elicited on pressure at inner angle of orbit or supra-orbital region.

Trans-illumination of frontal sinus was negative. The exostosis was removed easily with the result that the pain was decidedly relieved. One month later he returned complaining that the pain had returned and that there was a slight swelling on the right side near the root of the nose. I found that there was a rather hard swelling near the angle of the orbit and above the inner canthus. Examination of the nose showed the middle turbinated body swollen and tender. He was given a solution of adrenalin chloride 1-10000 and told to use it freely in the right side of the nose with a nasal cup. After two weeks' treatment with this solution he reported to me, and I found that the swelling had entirely disappeared as had his subjective symptoms. February 18, he again appeared at my office and this time with a swelling of considerable size at the site of the previous one, painful and tender on pressure, and with marked œdema of the upper lid. There could be little doubt as to the presence of pus and he was told to be ready for operation 24 hours later. During the day and night previous to his appointment for operative procedure, the pain became intense and he informed me on my arrival that the swelling had broken and he was all right. I found, indeed, that it had broken and that his eye was suffused with pus. He was etherized and a probe went through the external opening alongside the eye ball and some where into the nose. The external opening was enlarged, a fair sized drainage tube was insinuated alongside the probe and upon washing through this tube the solution appeared in the other side of the nose. He had no further symptoms of pain or discomfort and the foul smell entirely disappeared. Ten days later I opened the anterior ethmoid cells and brought the drainage tube down through the same side of the nose as that in which the orbital swelling had occurred. The subsequent history was uneventful and the patient was discharged March 15, with very little scar externally and a complete absence of pain and disagreeable odor.

The interesting points were the lack of diagnostic discharge from the nose although this was a chronic case of ethmoiditis, the subsidence of the first orbital swelling, under the use of the adrenalin chloride, and the passage of the drainage tube through the ethmoid cells of the right side through the septum into the left nasal cavity, and the rapidity with which cicatrization took place after drainage was established.

Waterbury, Conn.

A REPORT OF FOUR OPERATED CASES OF SINUSITIS IN CHILDREN.*

BY LEWIS A. COFFIN, M.D., NEW YORK.
Surgeon to the Manhattan Eye, Ear and Throat Hospital, New York.

Shortly after the meeting of this society one year ago it was my fortune to see two or three cases of sinusitis in children demanding operation. I was unable practically to find any literature on the subject of sinusitis in children and it is that fact which induces me to report four cases at this time.

Case I. The first case, J. V., a colored lad, aged 10, was referred to me from the Eye Department of the Manhattan Eye and Ear Hospital in May, 1903. Had a sinus opening near the inner canthus of the left eye where an opening had been made by a surgeon about one year previously on account of a tumor which had occurred at that point. The previous history of the boy was as follows: About one year previous to his first operation he had been a frequent sufferer from headache. His left eye was bloodshot, and a small tumor appeared between the nose and eye, with copious discharge from the nose. He was discharged from school on account of this condition. He visited various clinics, and finally the Eye Department of the Manhattan. The tumor was opened and after one year's treatment in a vain effort to close the wound, he was referred to me. I gave as my opinion that the boy had ethmoiditis and would recover only when the entire tract, including the sphenoid, had been curetted out. This operation was done on May 9. The boy left the hospital in less than one week, returning every other day for dressing until the latter part of June, when the tract had filled with granulation and the wound was entirely healed.

Case II. Willie C., aged 9, came into the Eye Department of the Manhattan Eye and Ear Hospital in the latter part of April, 1903, on account of extreme swelling of the upper lid of the right eye. On next visit there was a decided external exophthalmos. The case was referred to me and diagnosed as empyema of the ethmoid cells, and ordered ready for operation. Tumor ruptured between eye and nose while anti-operation bi-chloride pad was in situ. After

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ordinary incision and elevation of the periosteum, pus was found coming through an opening in the os planum. This opening was enlarged and the entire ethmoidal tract, including the sphenoid, was curetted. The dressing was changed at the end of four days and the patient allowed to go home, to report back every other day for dressing. The entire tract had filled with granulation and the wound healed on July 1. Headaches, of which the patient had complained for two years, ceased immediately after operation.

Previous History: Family history good. At four years of age the boy had scarlet fever followed by a middle ear disease with involvement of the mastoid. A successful mastoid operation was done. Patient was always catarrhal. At seven years of age had measles, after which the family physician advised removal of adenoids. Constantly complained of headaches, which his mother thought were due to the boy's disinclination to attend school. In the latter part of April, 1903, the headaches increased and he awoke one morning with the swollen eyelid, for the relief of which the above described operation was done.

In November, 1903, he was brought to the hospital with the left eye affected in the same manner as had been the right. I operated at once, simply curetting the ethmoidal tract, interfering neither with the frontal nor the sphenoidal sinus. The following day the patient had some fever, temperature being 101 and eye looked no better. Remaining the same for 48 hours, he was again etherized and the frontal sinus opened. It was large, extending about three-quarters of an inch toward the external angle of the eye and measuring fully one-third of an inch in antero-posterior diameter. It was filled with pus and a thick caseous matter. On the following morning the patient's general condition was very grave. The swelling of the eyelid and protrusion of eye, however, was much less. The boy died on the afternoon of that day—24 hours after the second operation. On autopsy no apparent cause could be found for death. The blood was not examined. He may have died from an acute sepsis. The sphenoidal sinus was found to be largely developed and filled with pus. The accompanying picture shows the boy just previous to operation on his left side, the scar on the right showing the site of the previous operation. Although the picture exaggerates the scar, there was more of a disfigurement than would have occurred had not the pus bored through the bone and soft parts previous to the operation.

Case III. The following history is sent me by Dr. W. L. Dayton, of Lincoln, Neb., who was present when I operated the last

time on the case just reported. Dr. Dayton gives the mother's account of the child's sickness, which is as follows:

"About the middle of November, 1902, my little daughter, aged 10, took a heavy cold, had chills, fever, aching bones and catarrh of the head. After the usual treatment she was up and about in a few days. On November 25, after getting up, she had a severe chill followed by high fever. The doctor was called and diagnosed pneumonia. Her breath was offensive. In a few hours she had a second chill, vomited and complained of severe frontal headache. Headache increased and centered over left eye. Repeated chills and fever continued, fever raging from 103 to 105 between November 25 and November 29. She was more or less delirious. November 26 eye closed and became swollen, I should say as large as an egg. Now diagnosed as erysipelas and so treated. I 'phoned you and

described case. You gave as your opinion that the child had ethmoiditis, ordered douching and so forth. Patient's fever continued high, arms and legs twitched piteously. About midnight of November 25, she roused and cried out, putting her hand to her head, and said it felt as if she had been cut with a knife. Temperature at this time was 105. Soon nose began to bleed and bled four or five times before morning, when temperature was 102, the lowest since sickness began, swelling not so large and pain much less. Temperature fell to 100 and continued at that point for several days. Breath, however, continued offensive and eye did not open. At end of a week temperature began to rise again. Swelling and pain also increased, and on December 7 we took train with the child for Lincoln and placed her on December 8 under your charge."

Dr. Dayton reports further on the case as follows:

"At the time she came to me I found distinct signs of the presence of pus and therefore made an incision into the tumor, which discharged a considerable amount of pus of an offensive odor. I made this incision through a portion of the upper lid, directing the point towards the lachrymal sac but not entering the sac. The relief from this was considerable, yet the secretion continued and the amount of pus present in her nose and throat daily, caused me to advise a more radical operation to get rid of the necrosed bone and open up the cells properly for drainage. This, under general anæsthesis, I did at the hospital on December 26, 1902, and found quite a good deal of necrosed tissue about the sinus and also found that the cells of the ethmoid were involved and the spaces easily curetted. The operation was very similar to the one you made while I was in New York. She got along very well from that time till about the middle of January, 1903. At this time she was coming to the office daily for treatment, the wound having about closed, when suddenly there appeared a pocket of pus which I believe to have been in the lid tissue which after being thoroughly curetted, made a slow but complete recovery, leaving but a very small mark and no disfigurement of the lid. The frontal sinus did not at any time seem to be involved.

Case IV. Through the kindness of Dr. T. J. Harris, I report the following case:

Baby X., aged six months, was referred on December 1, from the Presbyterian Hospital to the Manhattan Eye and Ear Hospital, with a history of having fallen from a high chair fourteen days before, striking the face. On admission the child, a well-nourished infant, had a temperature of 102 degrees fahr., and showed marked exophthalmos of the left eye. There was a small corneal ulcer. The case was transferred by Dr. Hepburn from the Eye to the Throat Department. Fluctuation was present beneath the orbit. The same day, under chloroform, Dr. Hepburn incised the abscess, evacuating a considerable quantity of bone pus. A probe entered the bony cavity of the orbit to a distance of an inch and a half. There was a thin purulent secretion from the nose. A probe also entered through a small incision in the canine fossa, the antrum of Highmore, which was discharging pus. It was believed we were dealing with disease of the ethmoid with perforation of the os planum. The abscess cavity was cleansed and packed. There were marked meningeal symptoms lasting for 48 hours in spite of the gentleness of the operation. Then the temperature fell to normal and the exophthalmos disappeared. The purulent discharge, however, continued. Ac-

cordingly ten days later, after consultation with Dr. L. A. Coffin, the child was again chloroformed and the antrum freely opened through the canine fossa. The roof was found entirely lacking. A probe entered freely into the orbit and moved the eyeball. After gentle curetting and removal of all granulation tissue, a drain of iodoform gauze was inserted. There was no reaction. Improvement was at once noticed. At the date of this writing the outer wound is closed and the amount of pus in the antrum noticeably reduced.

I shall take advantage of the opportunity which the report of this case by Dr. Harris afford me to briefly discuss the class of cases to which this one belongs.

In the year 1901, Dr. Emil Mayer, in a paper read before the American Laryngological Association, reported a case of empyema of the antrum of Highmore in a child two and a half years of age and read the collected histories of six or eight others ranging in ages from two weeks to five years. Dr. Mayer says:

"In all the reported cases the symptoms are the same, namely: fistula under the eye usually discharging pus; ectropion, one-sided purulent discharge from the nose with foul odor and eroded bone."

The ætiological factors reported were as follows: diphtheria, gonorrheal infection of the nose during birth; traumation at the time of birth, either from pressure due to impact against the arch of the pubis or from instruments, entrance of septic secretions in the facial cavities through laceration of skin at time of birth and the infection of the nose from a sore nipple of the mother.

Treatment is summed up as follows: Incision, curettage and thorough drainage. Dr. Mayer quotes at some length from an article by Dr. George Avellis, in which Dr. Avellis takes the ground that these are not cases of true antrum disease but rather cases of a general osteo-myelitis. Dr. Lennox Browne, on the other hand, is quoted as considering these cases as true types of antral empyema. For the reasons, pro and con, I would refer you to Dr. Mayer's paper in the Medical Record of May 10, 1901.

Dr. Mayer ranges himself on the side of Dr. Browne. From such a study as I have made of the subject I must agree with the position taken by Avellis except that he considers practically all of them to be of a tubercular character. I wish to say, however, that I have not read Dr. Avellis' article except as quoted by Dr. Mayer. I take this position for the following reasons:

First. The position of the antrum in infants and young children is such that were it to be so diseased as to fill up and burst it would not rupture on the face under the eye. It would certainly either rup-

ture into the orbit or nostril with the chances in favor of its opening into the nostril from the general cavity of which it is separated by a simple membrane. There is no antrum under the orbit during the first year of life.

Among the symptoms given with the report of most of the cases was the escape of pus from about the alveolar process of the superior maxillary and sometimes the noticeable swelling of the palate and superior maxillary wall. None of these symptoms could be referred to the antrum as situated in a young child.

Further as to the etiology. How much more easily might an alveolar cavity or the bone itself be infected by trauma, sore nipples, gonorrhea and diphtheria. As to treatment too, I doubt one's ability to curette the antrum in a young child and much more to drain it.

As to the case reported by Dr. Harris, at the time I saw it pus was coming down from one of the alveoli. It was through this cavity that I advised Dr. Harris to curette. At that time I supposed that the antrum was directly above and Dr. Harris reported to me after the operation that he had easily gone through the entire antrum into the orbit. Since investigating the matter by something over a dozen or more dissections I am sure that he went direct from the tooth cavity into the orbit, and in this opinion I am confident Dr. Harris now concurs.

49 West 50th Street.

PURULENT OTITIS MEDIA COMPLICATING TYPHOID FEVER.

BY EWING W. DAY, M.D., & CHEVALIER JACKSON, M.D., PITTSBURG, PA.

(*Continued from the October, 1904, number.*)

It is unnecessary before this learned body to review the pathology of acute purulent otitis media, as you are familiar with the stages of vascular engorgement followed closely by transudation of blood fluids, the migration of white blood cells and the pouring out of catarrhal secretions, etc. What we have classed as the slow type of cases seemed in the absence of autopsies to be pathologically the same as that of acute otitis media, occurring independent of typhoid fever, except that it was a very intense grade of inflammation. The two types of cases, the slow and the fulminating after the end of about a week or ten days assumed the same pathological state so far as the gross pathology could be conjectured from the naked eye appearances. The difference was in the rapidity of onset. The fulminating cases reached in a day, the stage that the cases of slow type reached in four or six days. The naked eye appearance which is all the source of information as to pathology that we have to offer was partially described under "symptomatology." Some further observations follow: The mucosa of the tympanum as seen through incisions and perforations in the membrana tympani, was, in the slow cases, sometimes deep red in the later stages, always so in the early stages. Frequently in ten days or two weeks the membrane would become pale and edematous, as though covered with flabby granulations which were pouring out pus. In many of all three classes of cases, large masses of pseudo-membranous exudate had to be wiped away from the fundus of the canal in the early days of the suppuration. It did not leave a bleeding surface. Microscopical examination of this substance showed it to be exfoliated epithelium, with, in some instances a fribrinous net work. In six cases of suppurative otitis, on the second day the membrana tympani was incised all round the tympanic ring. After the bleeding had been stopped with dry cotton tampons the edge of the membrane was turned up with a probe in successive portions and a careful examination of the atrial mucosa made. In five other cases the membrana tympani was cut in quadrant flaps by a vertical incision from top to bottom of the tympanic ring anterior to the malleus; a horizontal incision crossing this from

anterior to posterior periphery just below the umbo; and a third incision vertically close to the malleus posteriorly. These two plans of incision permitted, after hemorrhage stopped, a free inspection of the atrial mucosa. In all these cases the membrane was bulging with the presence of fluid discharges. Inspection showed three different states of the mucosa.

(a) Intensely reddened and inflamed with slight swelling associated with sero-sanguinolent discharge.

(b) The same with gray sloughing patches of exudate looking in spots as if touched with silver nitrate.

(c) Intensely swollen, rather pale œdematous mucosa that obliterated all landmarks. The fundus of the canal looking as if filled with exuberant granulations.

These eleven cases were not examined until after the appearance of the discharge. They had not complained of pain and they occurred during a period when no typhoid cases were being examined aurally, unless ear symptoms were noted by the nurses or internes, so that it could not be stated to which type they belonged. Furthermore, they occurred before it was realized that there were two types of cases in addition to the hemorrhagic. In one very acute case of the fulminating type, there seemed to be an acute osteitis. The malleus and incus seemed to become necrotic and their attachments sloughed away. They both were wiped out on a cotton applicator. In this case the walls became slightly involved along the lower outer attic wall, where a small sequestrum came away, leaving a notch. This case recovered without operation apparently because of the ample drainage afforded.

In four cases of purpuric typhoid fever, in which the skin surface was mottled in various locations with dark blue spots, the mucosa of the pharynx, naso-pharynx, and larynx were seen to be spotted in the same way. The Eustachian eminence were free from the spots in all four cases. The mucosa of the ear in all four cases was examined as well as possible through tympanic perforations and was seen to be spotted with blue black discolorations in one case. In one other case the entire middle ear as far as could be seen was slate colored blending to brownish black and black anteriorly. This case did not bleed from the ear. It did bleed copiously from the nose. Another case bled freely from the ear. No exact source of hemorrhage could be located. The blood seemed to ooze through the blackened membrane everywhere. The blood was brown in color and oozed through

a tight gauze plug like water. There seemed to be changes in the blood which deprived it of its coagulability. The hemorrhage was only stopped by a cotton plug dipped in collodion forced tightly into place immediately after removing a drying plug of gauze. This corked the canal like a cork in a bottle. The pathology of the hemorrhage cases is not clear. Evidently there was a leaking out of blood through the wall of the mucosal vessels and through the epithelium into the cavity of the middle ear, which blood afforded an excellent culture medium for the proliferation of pus cocci. Two such cases were seen in their hemorrhagic stage, and watched until pus formed before evacuation by incision. No case of hemorrhage with subsequent absorption was seen. In another class of hemorrhagic cases of which five were seen, the hemorrhage was evidently under the epithelium. In two cases the blebs were incised, in three they were allowed to burst. The result was the same—an acute suppurative otitis media followed in all the hemorrhagic cases of whatever form. If it is assumed that the pathology of the blebs of the non-purpuric cases was the same as in the purpuric cases, the pathology is easily understood. But there is no evidence of this. The blebs were like little vesicles filled with a thin sero-sanguinolent fluid. When occurring on the drum membrane evidently the accummulation was between the layers. When the bleb was continued outward on to the canal wall, the surface of the bleb did not show any line of demarcation between what had been membranic epithelium and what had been parietal epithelium. The contents of the blebs was always apparently the same—fluid about the color of venous blood or slightly darker, but thinner and with no tendency to coagulate. The blebs were not accumulations in the anterior or posterior or Van Trœltsch's pockets. In one case of post suppurative sclerosis, many adhesions extending in every direction were found by the probe introduced through a rather small perforation, located just posterior to the umbo. All discharge had ceased seven years before after having continued two years following an attack of la grippe. This case was closely watched with special interest on account of the difficulty of the maintenance of drainage from the attic and aditus, should a suppurative inflammation occur. Two attempts at culture proved the middle ear sterile at the time the patient was admitted in the second week of his typhoid fever. Two weeks later he developed acute inflammation of the formerly diseased ear. The discharge escaped through the old perforation as soon as formed and never seemed to involve the attic. Of three other cases all developed a recrudescence of suppuration. One developed mastoid

empyema, in which on opening it no sign of Sclerosing osteitis was found though there was a history of years chronic otitis.

The permanent impairment of hearing with lowering of the upper tone limit, in ten cases was doubtless due to small celled infiltration into some of the labyrinthine tissues. Whether this labyrinthine involvement was primary, due to irritation by the toxines in the blood circulating through the parts, or whether it was by extension from the middle ear, it is impossible to say as to all the cases. In three cases, however, this was a primary (not an extensionary) lesion in the labyrinth, for the middle ear was not affected. In four cases it was certainly an extension from the middle ear for there was necrosis of the inner (petrous) wall. Of course, in the latter cases it was impossible to say that there was no labyrinthine inflammation prior to the pyogenic extension. But the hearing had not been much affected until the onset of the median otitis.

In three cases, exuberant granulation pushed the drum head until it bulged as though retained secretions were behind it. Deeming the small perforation an insufficient outlet, a free incision was made, when instead of pus, a granulating mass pushed through like we see sometimes in chronic otitis media. This occurred after four, five and eight weeks, respectively, of otitis and was associated with dead bone in each instance.

Two cases when discharged had necrosis of the long process of the malleus, which refused to heal, and an operation was not permitted. Bone necrosis when occurring in the ossicles as it did in four cases was due, doubtless, more to interference with blood supply from pressure from the swollen mucosa than to simple virulence of the infection. It appeared in the walls in six cases, in three of which the process was constantly under observation. In these three cases the necrosis resulted after three, five and seven weeks respectively, of otitis. It resulted from the gradual deepening of an erosion that started as a superficial slough of the mucosa. When the bone was reached, the surface of the erosion was covered with a granular looking coating that looked not unlike mucous membrane, but through which the denuded bone could be felt with the probe. So far as direct observation was possible, the process always started superficially in the mucosa and not as an osteitis, though the exquisite tenderness in the early stages may possibly have been an osteitis. In one case the usual resisting power of the connective tissue at the vault was unavailing to ward off the streptococcal invasion and extensive necrosis followed. In this case when the mastoid was opened a large portion of the tegmen tympani was ab-

sent, but there was only a slight pachymeningitis which soon subsided.

ETIOLOGY.

Various theories backed by observations are advanced in the literature.

Demeurisse, who believed the otitis of la grippe and the acute infections contagious, thought the contagion occurred by the route "naso-tubaire."

Bezold classifies the causes as follows: Direct extension of naso-pharyngeal inflammation by continuity of tissue through the Eustachian tube; entrance of septic secretions into the middle ear through the tube; embolism in the mucous membrane from endocarditis or peripheral pyogenic-thrombi.

Politzer accepts Bezold's classification of causes.

Keen says it is "obviously a pyogenic infection from the throat." Hengst attributes it in part, to exposure of the side of the head to draughts; carelessness in washing and bathing; allowing the water to pass into the nose or into the external ears.

Hoffman believes otitis media purulenta in typhoid fever to be an extension from the naso-pharynx. Von Trœltsch and Blau consider dryness of the mouth and throat by closing the tubes with thickened dried mucus the chief factor.

Schwartz believes the trouble entirely independent of the tubes and to be a primary inflammation of the tympanic mucosa. Where tubal closure exists, he believes it is due to swelling at the tympanic end of the tube. Hartman considers the tympanic inflammation a specific typhoid fever inflammation similar to that in the intestines. This view is hardly tenable in view of the facts, first, that there is no lymphoid tissue in the tympanic cavity at all similar to Peyers patches, and second, the frequent onset of the ear inflammation is at a time when the specific enteric inflammation is subsiding. Of course, re-infections of the general malady occur at this stage and the ear inflammation might be regarded in this light as a late infection.

The following observations were made by the writers:

Among 41 cases of typhoid fever in private rooms of the Western Pennsylvania Hospital, one case, only, of otitis media (2.4%) developed. In the surgical wards but two cases developed in the house; one patient was of very low vitality because of anemia in the last stages of chronic nephritis, and the other seemed to have been infected from the naso-pharynx during anesthesia for an abdominal operation.

In the only case of otitis media purulenta that developed in the medical wards during the year, in a disease other than typhoid fever, was in a case of pneumonia and was due to the pneumo-coccus.

All these observations point to a predisposing, if not an exciting factor in typhoid fever that does not exist in other ailments. This factor, whatever it may be, is not usually present in the first three weeks. Bearing on this point, 93% of the purulent otitis media cases occurred after the 21st day; 8% between the 12th and 21st days. Of 20 cases of typhoid fever that died before the 21st day, no ear suppuration was noted. Of 20 cases that died between the 21st and 31st day of the disease, two had suppurating ears.

Naturally the causes are classified into predisposing and exciting factors. Whatever these may be, they never both exist prior to the 10th day of the general infection (not counting the prodromal period) and very rarely before the third week. This must certainly point strongly to the predominant etiologic factor.

What are the characteristics of the third week and the following weeks of typhoid fever as compared with the earlier period? Sensitiveness to cold, a rapid, often sudden emaciation, lowest resistance of the tissues and juices, thrombotic phenomena, glandular disturbance, pneumonia and broncho-pneumonia beginning inflammatory and purulent troubles, separation of the sloughs from the enteric lesions. The worst of the high temperature is over, but its damages remain.

In looking over the field of etiologic possibilities, a long list suggests itself.

Predisposing Factors.

1. Dorsal decubitus—a factor in drainage.
2. Swallowing, semi-somnolent and in a recumbent position, frequent and prolonged because of liquid diet. Repeated efforts because of difficulty in swallowing.
3. Acute catarrhal discharges in nose and naso-pharynx and ear in all typhoid fever cases. A good culture medium and an excitement of efforts at clearing by blowing the nose and hawking.
4. Lowered resistance, and weaker phagocytosis (or its equivalent)
   (a) Lessened tubal protective activity, weakened cilia,
   (b) Weakened resistance of tympanic tissues.
5. Increased virulence of organisms proliferating in the tympanic incubator.
6. Tubal closure.

7. Abnormal patency of the Eustachian tube.
   (a) Present before illness,
   (b) Due to absorption as a part of the general emaciation,
   (c) Due to ulceration and sloughing of tubal mucosa,
   (d) Due to violent activity of the levator palati mollis (temporary.)
8. Intensity of the general infection.
   (a) Pyrexia,
9. (b) Toxemia.
10. Perforated drum head from previous suppuration.
    (a) Admitting infection,
    (b) Facilitating infection per tubam.
11. Pretyphoid chronic catarrhal and purulent otitis.
12. Anemia of vascular tissue of nose, resulting in lessened filtration of inspired air, thus favoring infection of the naso-pharyngeal secretions.
13. Draughts of air especially when patient is perspiring, producing acute catarrhal otitis media, later becoming purulent by infection.
14. Hydrotherapy,
    (a) sponging
    (b) tubbing
    (c) wet pack
    (d) ice pack
    (e) ice bag on head.
15. Drugs.
16. Age.
17. Sex.
18. Nationality.
19. Occupation.
20. Impacted cerumen.
21. Associated typhoid and pre-typhoid disease of nose and throat.

Exciting Factors.

1. Extension by continuity of tissue.
2. Infection via
   (a) blood, infective emboli or typhoid bacilli floating free.
   (b) Eustachian tube
   (c) External auditory canal
   (d) Petro squamosal fissure
   (e) Lymphatics (Zaufel's lymph plexus).
3. Thrombosis
   (a) Aseptic clot
   (b) Infective emboli (classified under infection).

4. Sloughing of purpuric areas.
5. Erysipelas.

Let us take up these possibilities more in detail. Number one needs no comment further than to note that of 20 severe typhoid fever cases watched, they averaged 19 hours out of the 24 on their backs.

That swallowing facilitates infection by way of the tube seems likely. Swallowing is often difficult with typhoid fever cases, and the violent efforts bring into great activity the tubal dilating muscle, the tensor palati mollis. (spheno-salingo, staphylimes.)

The frequent, almost usual presence of a catarrhal state of the mucosa of the upper air passages in typhoid fever, is well known and was confirmed in these observations. But not so the ear. Out of 280 patients examined, 221 (78.9%) had catarrhal conditions of the upper air passages, while 21 out of 220 pairs (9.5%) of non-suppurative ears had evidence of a catarrhal state of the tympanic mucosa. From this, it appears that while the mucosa in the naso-pharynx may afford a culture medium for infective pus organisms, the tympanic secretions do not.

In regard to ærial infection of the naso-pharynx, the following observations are worthy of note:

C ward in which most of the cases here reported, occurred, is the oldest ward in the hospital. It is overcrowded practically all the time. On account of the crowded condition of the entire hospital it is not possible to remove the patients frequently for fumigation of the ward. Under these conditions it is not surprising to find in its air more pus organisms than in any other ward in the house.

In plate cultures made by exposure to the air of the ward for 1 hour and 40 minutes, large numbers of pyogenic organisms were found in the air. Approximately the same numbers were found in the medical wards of the other hospitals of the same age. The new hospitals showed more favorably. But even in these there were too many pyogenic organisms.

The accumulation of infective muco-pus in the naso-pharynx beause of the patient's feeble condition, being too weak to execute the necessary hawking, was a factor favoring infection via tubæ.

(TO BE CONTINUED.)

BOOK REVIEWS.

Diseases of the Nose, Throat and Ear and their Accessory Cavities. By SETH SCOTT BISHOP, M.D., D.C.L., LL.D., Author of "The Ear and its Diseases;" Honorary President of the Faculty and Professor of Diseases of the Nose, Throat, and Ear in the Illinois Medical College; Professor in the Chicago Post-graduate Medical School and Hospital; Surgeon to the Post-graduate Hospital and to the Illinois Hospital; Consulting Surgeon to the Mary Thompson Hospital, to the Illinois Masonic Orphans' Home, and to the Silver Cross Hospital of Joliet, etc. Third Edition. Thoroughly Revised, Rearranged, and Enlarged. Illustrated with 94 Colored Lithographs and 230 Additional Illustrations. 564 Pages, Royal Octavo. Price, Extra Cloth, $4.00, net; Sheep or Half-russia, $5.00, net. F. A. Davis Company, Publishers, 1914-16 Cherry st., Philadelphia.

No more convincing proof of the popularity and acceptability of this concise, thorough and essentially American text book on diseases of the nose, throat and ear can be presented, than the fact that the third thoroughly revised and enlarged edition now makes its appearance in such short order after the publication of the first edition.

Much credit is due the author for his impartial and frequent recognition and reference to the best work of American writers, as he most aptly states in his preface, "Our own countrymen are too often overlooked, and their conscientious and meritorious labor meets with too little encouragement at home as well as abroad." By the expression of this sentiment and the effort to bring the good work of his American colleagues more prominently to notice, Dr. Bishop has especially earned the approval of the American laryngological and otological profession.

To the student and general practitioner, this volume is invaluable as it presents clearly and concisely more subject matter in this field than can be obtained in any other American text book.

By far the larger part of the volume is devoted to the nose and throat, but the ear section is given due attention. We trust soon to welcome the author's companion volume, 'The Ear and its Diseases." M. A. G.

Surgical Anatomy of the Head and Neck. By JOHN B. DEAVER, M.D., Surgeon-in-chief to the German Hospital, Philadelphia. Illustrated by 177 plates nearly all drawn from original dissection: Neck, Mouth, Pharynx, Larynx, Nose, Orbit, Eyeball, Organ of Hearing, Brain, Back of Neck, Cranium, Scalp, Face. Publishers, P. Blakiston's Son & Co., 1012 Walnut street, Philadelphia, Pa. Price $12.00, net.

This volume of Dr. Deaver's complete work on surgical anatomy, treats especially of the regions which are of greatest interest to nose, throat and ear practitioners. The volume is essentially an atlas of surgical anatomy with especially prepared illustrations drawn from dissection, made for the purpose. They are accurate and clear, and represent the best typographer's art.

This atlas is of inestimable value to the operating laryngologist and otologist for study of the intimate and intricate anatomy of the head and neck,

and the many surgical land-marks of these areas. The full-page plates of sections and dissections of the middle ear cavity and its accessory areas deserve special mention, as they are unusually clear and instructive and are distinctly original. Several unusually fine plates of the nasal fossæ and accessory sinuses should also have special mention.

The musculature and anatomical relations of the mouth and palate are also beautifully illustrated. The text is clear and concise. In some instances more detailed description of the illustrations might be desirable.

This classic volume should be in the library of every laryngologist and otologist. M. A. G.

Adenoids. By WYATT WINGRAVE, M. D. Durh., M. R. C. S. Eng. Late President British Laryngological and Rhinological Association; Physician and Pathologist, Central London Throat and Ear Hospital. Pp. 128, with 32 figures. Price 2s. 6d., net.

This excellent monograph presents the all-important and ever-present subject of adenoids in its anatomical, pathological, clinical and technical aspects. The extensive experiences of Dr. Wingrave with this subject especially qualifies him in the presentation of such a monograph, and it is perhaps a more complete account of adenoids than can be found in any text book.

M. A. G.

Hand-Book of the Anatomy and Diseases of the Eye and Ear. For Students and Practitioners. By D. B. St. JOHN ROOSA, M.D.,LL.D., Professor of Diseases of the Eye and Ear in the New York Post-graduate Medical School; formerly President of the New York Academy of Medicine, etc., and A. EDWARD DAVIS, A.M., M.D., Professor of Diseases of the Eye in the New York Post-graduate Medical School; Fellow of the New York Academy of Medicine. 300 pages, square, 12 mo. Price, extra cloth, $1.00, net. F. A. Davis Company, Publishers, 1914-16 Cherry street, Philadelphia, Pa.

This little volume seems to occupy a place half way between a compend and a text book and as such serves its purpose well. We have previously commented on the association in one volume, of the subjects of ophthalmology and otology, especially in the larger treatises and classic text books; and we are surprised now to find that even in the small hand-book this association of the eye and ear is still maintained.

This volume is essentially a pocket manual for the under-graduate and perhaps for the general practitioner; but for the special practitioner in this field it is perhaps too abbreviated. M. A. G.

Mental Defectives—Their History, Treatment and Training. By MARTIN W. BARR, M.D., Chief Physician Pennsylvania Training School for Feeble-Minded Children, Elwyn, Pa. Illustrated by 53 full page plates. Publisher, P. Blakiston's Son & Co, Philadelphia.

The principles of treatment and of training of feeble-minded children is a section of medical science which has not received the attention it demands, and is therefore still in an evolutionary stage.

The classic work of Dr. Barr in presenting this volume of the history, treatment and training of mental defectives, should receive most favorable recognition at the hands of the profession. It is the first American work of importance on this subject to make its appearance. In the practice of laryngology and otology we are often asked for advice concerning the proper training and development of backward children or those defective in speech or hearing. This volume is especially worthy the perusal of every reader of THE LARYNGOSCOPE, as it will certainly bring him in closer touch with a subject about which there is still much to be learned. Dr. Barr of the Pennsylvania Training School for Feeble-Minded Children presents much valuable and important data in his classic book. M. A. G.